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# Useful Materials: PXRF Analysis of 17th-Century Flat Glass from Plymouth Colony

Grace E. Bello

USEFUL MATERIALS: PXRF ANALYSIS OF $17^{TH}$-CENTURY

FLAT GLASS FROM PLYMOUTH COLONY

A Thesis Presented

by

GRACE E. BELLO

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ABSTRACT

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August 2020

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This master's thesis uses a portable X-Ray Fluorescence (pXRF) spectrometer to date and identify flat green glass fragments from English colonial sites in New England. Three sites from the $17^{th}$-century Plymouth Colony produced flat glass tested in this thesis. These sites include the Burial Hill site (164 samples), the Alden site (764 samples), and the Standish site (21 samples). Based on the pXRF testing conducted, it was determined that $17^{th}$-century flat glass samples can be identified and dated using elemental and physical characteristics. Green window glass produced between 1567 and 1700 can be identified by the presence of a relative strontium content of less than 29,000 counts, a relative lead content less than 4,293 counts, and a thickness of less than 3 mm. Green case bottle glass that was produced between 1567 and 1700 can be identified by a relative strontium content less than 29,000 counts and a relative lead content more than 4,293 counts. Flat glass fragments with strontium counts higher than 29,000 cannot be identified but can be dated to being produced between 1660 and 1835. These characteristics were used to date 949 flat glass fragments from the three sites listed above and to identify 869 of those fragments. This identification

and dating analysis concludes that the residents of the Burial Hill site likely had easier access to newer and a wider variety of goods compared to the Alden site. Flat glass samples from the Standish site were deposited after the site was demolished. Finally, the variable lead and strontium composition in flat glass fragments at these sites indicates the possibility of an experimental time period in English glass production during the $17^{th}$ century.

## ACKNOWLEDGEMENTS

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# DEDICATION

This work is dedicated to my parents,

Rebekkah and Bill Bello.

Your love is the lead and strontium to my life.

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# CHAPTER 1

# OVERVIEW AND INTRODUCTION

During the 17th century, an evolution in English flat glass manufacturing caused a growth in the variety and availability of glass products that were accessible in England and its colonies. Due to this growth, flat glass fragments are commonly discovered at archaeological sites dating to the colonial era in the United States. Oddly enough, this is one reason glass is the perfect material for detailed quantitative analysis. This is because, if the material is ubiquitous enough that it is found at most sites, comparisons between those sites become easier. These comparisons can provide new data about the development of the English glass industry and England's trade with its colonies.

While many archaeologists think that there is little to be learned from flat glass at historic sites, it is a material type that is rich in elemental variations. These variations are another reason glass can be used for technical analysis, as elemental differences between fragments can be studied through portable X-Ray Fluorescence Spectrometer (pXRF) testing. A pXRF measures the elemental composition of materials by using x-rays to create photon energies distinct to specific elements. For this thesis, relative groupings of strontium and lead compositions were used to establish group characteristics of flat glass fragments without a unit calibration. Based on major manufacturing changes in the English glass industry that occurred during the 17th century, the relative composition of these two elements can be used to identify and date green flat glass artifacts as window glass or case bottle fragments.

This thesis focuses on sites in New England, within the bounds of the original Plymouth Colony, through detailed technical analysis of the flat glass products excavated at these sites. Plymouth Colony was established mostly to lay claim to the not-yet depleted resources of the region, such as timber, fish, and fur. The first settlement within the colony was established in 1620 by a group of English religious separatists and colonists seeking economic advancement (Davis 1908:213-229).

Plymouth colony can be used to draw connections between colonists and their English heritage as archaeological sites within the colony have been extensively excavated and a substantial amount of primary and secondary source documentation exists regarding the English occupation of the area. This thesis assesses these connections by examining the flat glass artifacts excavated at three early English domestic sites within the colony, the Burial Hill site, the Alden Site, and the Standish Site. In total this thesis tested 949 flat glass fragments from these three sites.

Flat glass analysis is one way that archaeologists have yet to explore studying the complicated connection between England and its colonies. This thesis seeks to test the validity of using variations in glass composition to understand this connection between the colonies and their mother country by answering the following questions:

- As production of glass evolves and diversifies, can pXRF glass analysis aid in dating archaeological artifacts or deposits?

- Can this same pXRF testing also be used to identify different glass artifact types?
- Can analyzing flat glass artifacts at the Burial Hill site, Alden site, and Standish Site in Plymouth Colony, be used to better understand tangible material connections between England and its colonies?
- How are changes in English glass production during the 17th century represented in the colonies, especially as relationships between the colonies and England change?

During the 17th century, while these sites were occupied by English colonists, window glass became a requirement rather than a luxury within homes and places of work (Wilson 1972:5-7). As early as 1634, William Wood, a Massachusetts Bay Colony resident and author of "New England's Prospect," wrote that "Glasse ought not to be forgotten of any that desire to benefit themselves or the country: if he be well leaded, and carefully pack't up I know of no commodity better for portage of sayle" (Wilson 1972:6). Window glass was so coveted in the colonies, as it was expensive and difficult to ship, there are documented pirate raids during the mid-17th century, where windows were looted from homes instead of being destroyed (Wilson 1976: 163). These references demonstrate the importance of window glass to colonists throughout the 17th century and their continued desire to consume glass products.

While colonists were wanting to consume these products, English manufacturing of marketable goods was going through a revolution of production. This revolution affected multiple industries including glass production, which expanded and evolved during the 16th and 17th centuries. An economic upturn that began during Queen Elizabeth I's reign enabled an increase in industrial monopolies and brought craftsmen from the continent to England seeking better economic prosperity (Godfrey 1975:38-40). With this emigration of craftsmen, came a mixing of at least three different glass production styles which changed the elemental composition of all types of glass (Godfrey 1975:16-18). In particular, the introduction of kelp ash as a flux and variations in the use of raw lead are important raw material changes that effected elemental composition of window glass and some green glass vessel products.

The use of kelp ash as a flux in window glass production is first documented in “The Art of Glass,” after it was translated into English by Christopher Marret in 1662. This flux leaves a significant amount of strontium in the glass product as a trace impurity. Consequently, as there is an approximate date of introduction of kelp ash use, this notable strontium content can be used to date glass produced with kelp ash as a flux. This creates the possibility that other types of glass products can be dated using relative strontium content. Therefore, if a glass artifact produces a comparatively high strontium content through pXRF testing, it likely was produced after 1660. Conversely, a relatively low strontium content determined through pXRF testing would suggest a production date between 1567 and 1700.

During the course of data collection for this thesis, it was discovered that lead can be used as an identifying tool for distinguishing highly fragmented flat glass fragments as case bottle versus window glass fragments. According to Eleanor Godfrey in “The Development of English Glass Making: 1560-1640,” (1975:225-229) thin walled, square green glass bottles, called cased bottles or case bottles, were made in a range of glass houses in England, including ones producing window glass. This study found that case bottles have a relatively high lead content compared to window glass, which have a comparably low lead content. Throughout the history of glass production, lead was added as a part of the production recipe for different reasons. The use of lead in a glass melt could be due to its use as a strengthener, decolorizer or flux in glass production (Godfrey 1975:161; Dungworth et al. 2006:453-454).

This discovery of lead as an identifier for specific glass products was found to be useful only in flat glass fragments that have a relatively low strontium content (1567-1700 glass). This suggests important conclusions about changes in English glass production during the 17$^{th}$ century. These important changes in glass production, with the addition of lead and kelp ash use, left indicative elemental markers within the glass products, which can be used as trace elements in identifying and dating glass fragments from this period found at English colonial archaeological sites.

This study of English products in the colonies can be used to better understand the complicated connection between colonists and their home countries. While many historians and archaeologists have discussed the evolution of a colonial culture through a built landscape (Candee 1969; Deetz 1976, 1996; Cummings 1979; Upton 1979; Donnelly 1979, 2005), a study of how that built landscape was ornamented with newly industrialized products from England can aid in developing an image of the engrained material connections between England and its colonies. This can be done through the dating and identifying of industrially produced English window glass and case bottle products found at English colonial sites.

**Chapter Summaries**

Chapter 2 presents the historic background of the establishment of Plymouth Colony and assess the colonial occupation at the three archaeological sites discussed in this thesis. Within this background presentation there is a discussion of the archaeological investigations conducted at these sites. Once the historic and archaeological background of Plymouth Colony is established, a brief history of glass production is summarized, accompanied by an examination of glass consumption during the 17$^{th}$ century in England and its colonies. Finally, this chapter concludes with a summary of work conducted on window glass using pXRF technology.

Chapter 3 presents the technological background and limitations of pXRF testing. Included in this discussion is a breakdown of why a pXRF unit calibration was not needed for this method. This chapter also details the specifications of glass fragments that can be studied with this technique and presents the process that is required to conduct this type of pXRF analysis. In addition, the system used in this thesis for assessing flat glass fragments for identifiable characteristics and corrosion is established. Following this is an assessment of the control tests used to create this method, which delineates the limitations of this study.

Chapter 4 introduces the final results of the pXRF testing, followed by statistical validation of the analysis. This chapter first presents the total results of the pXRF testing before assessing these results by site. This is followed by a discussion of the initial interpretations that can be drawn from relative strontium content as a dating tool. Then, an analysis of the lead content of artifacts found at the three sites is presented, which leads into the statistical testing that verifies the accuracy of using lead content to identify window glass versus case bottle fragments.

Chapter 5 then uses the discussion and presentation of strontium and lead content interpretations to build characteristics for identifying and dating all the flat glass fragments that were tested in this thesis. This chapter then establishes concluding interpretations based on the identified and dated flat glass fragments from the three sites.

Chapter 6 summarizes the conclusions presented in chapter 4 and 5, along with a summary of the important characteristics that can be used for identifying and dating flat glass fragments. This chapter also discusses future research opportunities and the final implications of the method and results for future analysis. Finally, this chapter evaluates this method's ability to answer the research questions listed above.

# CHAPTER 2

# BACKGROUND

Before presenting the archaeological excavations and material culture of the sites studied in this thesis, it is pertinent to examine the early history of Plymouth Colony. This examination is to place the three archaeological sites in the larger context of colonial history.

## Plymouth Colony Early History

After the reformation began in 1517, a long period followed of social, economic, and political upheaval which caused large migrations of Europeans seeking economic prosperity and asylum from religious persecution. During this time, a group of religious separatists left England for the Netherlands, where religious tolerance was practiced. A majority of this group was from the Midlands in England, specifically around Nottinghamshire. While living in England, members of this separatist congregation were fined, jailed and under surveillance from English officials for not following the current English law regarding religious practices (Davis 1908:3-19).

Once in the Netherlands, these separatists were not satisfied as their social and economic standing was lessened, the customs of the Dutch clashed with their English ideals, and there was an increase of anxieties about unrest throughout the country because of the ongoing Dutch Revolt. Therefore, the congregation sought a place where they could keep their families safe and practice their religion freely (Davis 1908:15-25; Darby 2001).

After 12 years in the Netherlands, the congregation was granted a patent to start a company that, through the sale of shares, purchased land on the east coast of the present day United States. A majority of the shares were sold to wealthy English merchants who wished to lay claim to natural resources, such as fish and fur, in North America. Smaller sets of shares were bought by prospective settlers who were comprised of both individuals from the congregation as well as other, non-religiously driven, English families and single men. These individuals and families were seeking economic and social advancement in the English colonies. All of the prospective settlers were promised that their shares in the company would be transferred into land claims once the colony was sufficiently established (Davis 1908:38-63).

After sailing for 66 days and exploring for an additional 47, the settlers were forced to build their settlement in present day Plymouth, MA, in late December 1620. The settlers established a small village on a hill that today is a combination of Burial Hill and Leyden St. in downtown Plymouth. Throughout the next seven years the settlers likely built post in ground and “foundation-on-ground” structures for dwelling and storage along Burial Hill and Leyden St. A fort was also built likely on top of Burial Hill which was accompanied by a palisade that surrounded the settlement (Dexter et al. 1865, Beaudry et al. 2003, Deetz and

Deetz 2000:179-184). Shown in the map below is the approximate location of where the settlers built the first nucleated settlement of Plymouth Colony. The size and shape of the settlement is unknown, but shown in Figure 1, is the general location of the occupied area.

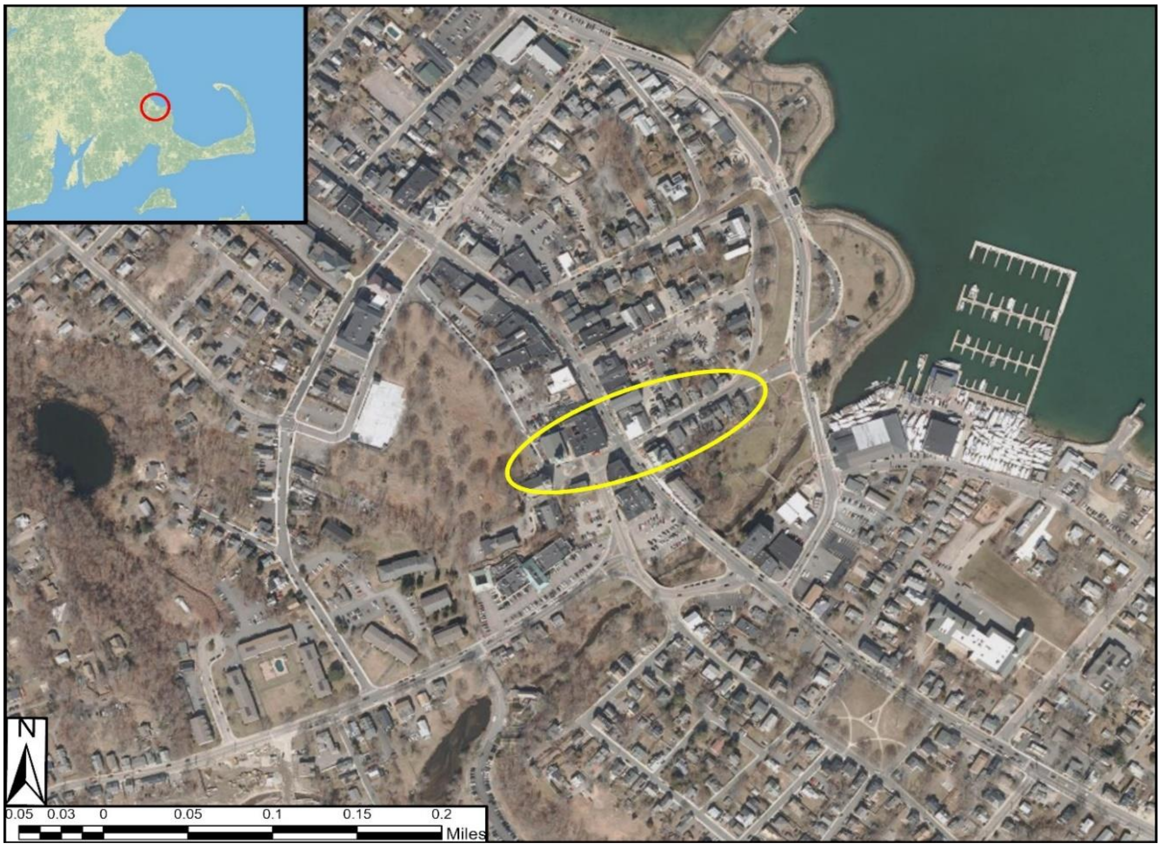


*Figure 1. A map of southeastern Massachusetts with the location of the 1620 village outlined.*

After the first winter, only 50 of the original 102 passengers remained. Among these 50 survivors were Captain Myles Standish, John Alden, and Priscilla Mullins (Dexter et al. 1865: 10-12). These individuals are the most likely early settlers associated with the archaeological site on Burial Hill, that is discussed in the following subsection of this thesis.

During 1627, the company that supported the settlement folded and colonists' shares were divided into land and cattle claims. At this time, most of the settlers moved from the original settlement to their larger land holdings that were in present day Duxbury, Marshfield, Kingston and Plymouth, MA. It is likely that most families built homes on these new plots but returned to the first settlement to fulfil their civil and religious duties on a regular basis until 1632. During this year, many settlers who had moved out of the initial settlement requested to be relinquished from these requirements (Davis 1908:293; Stratton 1986:37-41). These satellite land claims are the focus of the other two archaeological sites discussed in this thesis and were also occupied by the individuals mentioned above, Standish, Alden, and Mullins.

The following sections dive further into the colonial occupation of the three archaeological sites discussed in this thesis and the flat glass material assemblages from those sites.

## Burial Hill History and Archaeological Investigation

The hill on which the separatists first built their homes between 1620 and 1627 is called today Burial Hill, but between the 17th through 19th centuries was often referred to as Fort Hill. This hill was occupied by Native peoples before the arrival of Europeans in varying capacities. Based on past and ongoing research, Burial Hill has been occupied by humans for thousands of years before European arrival through to the present day (Landon and Beranek 2019).

English alteration to the hill began in 1620 when, according to Edward Winslow, seven dwelling houses and four common buildings had been constructed in parallel rows along the hill within the first year of the settlement (Dexter et al. 1865:72, 132). By 1623, the number of houses grew to around 20, which includes four or five houses that were "fair and pleasant," as documented by a visitor to the colony, Emmanuel Altham (James 1963:24). These references are two major primary sources documenting what the houses on Burial Hill looked like during the first years of the settlement.

As the construction and outward appearance of the first settlement's buildings was seldom documented, personal letters of colonists are relied on to theorize the use of glass in the early years of the colony. The following is a quote from a Reverend Francis Higginson, the first minister in Salem, MA, who wrote twice between 1629 and 1630 requesting "glasse for windows, and many other things which were better for you to think of them than to want them here" (Wilson 1972:6). The type of windows Higginson is referring to is the common 17$^{th}$-century casement window that was an independent unit and very expensive to ship to the colonies due to its fragility. Based on this knowledge it can be concluded that in the first decade after the establishment of Plymouth Colony, glass windows were not likely a common occurrence. It is much more likely that windows would have been constructed from wooden mullions filled with oiled paper (Godfrey 1975:12; Scharfenberger 2004:61). The import rate of glass coming into New England in the mid to late 17$^{th}$ century is further explored in a following section.

After the first decade of colonial occupation, homes were likely reconstructed or updated to be more substantial for domestic, business or storage use in the future. While written documentation of what happened to those original houses does not exist, based on court records depicting the sale of land along Burial Hill from the 1630s, some conclusions can be drawn to determine the location of specific buildings originally constructed in the 1620s. These court records are an administrative history of Plymouth colony between 1627 to 1651, which includes details on the 1627 land division, civilian duties, as well as sale and purchase of land plots within the colony (Pulsifer 1861).

The physical area of interest to this thesis consists of plots of land, which are mentioned in the court records, that have recently been the subject to a large archaeological investigation in search for the remains of 17$^{th}$-century occupation in downtown Plymouth. The location of these plots of land can be seen in Figure 2. Based on research conducted for this excavation, it has been theorized that these areas were occupied by the Standish and Alden families during the 1620s. However, based on a lack of concrete documentation, it may never be possible to definitively determine that these plots of land were actually lived on by these families. This archaeological investigation is explained more thoroughly later in this chapter.

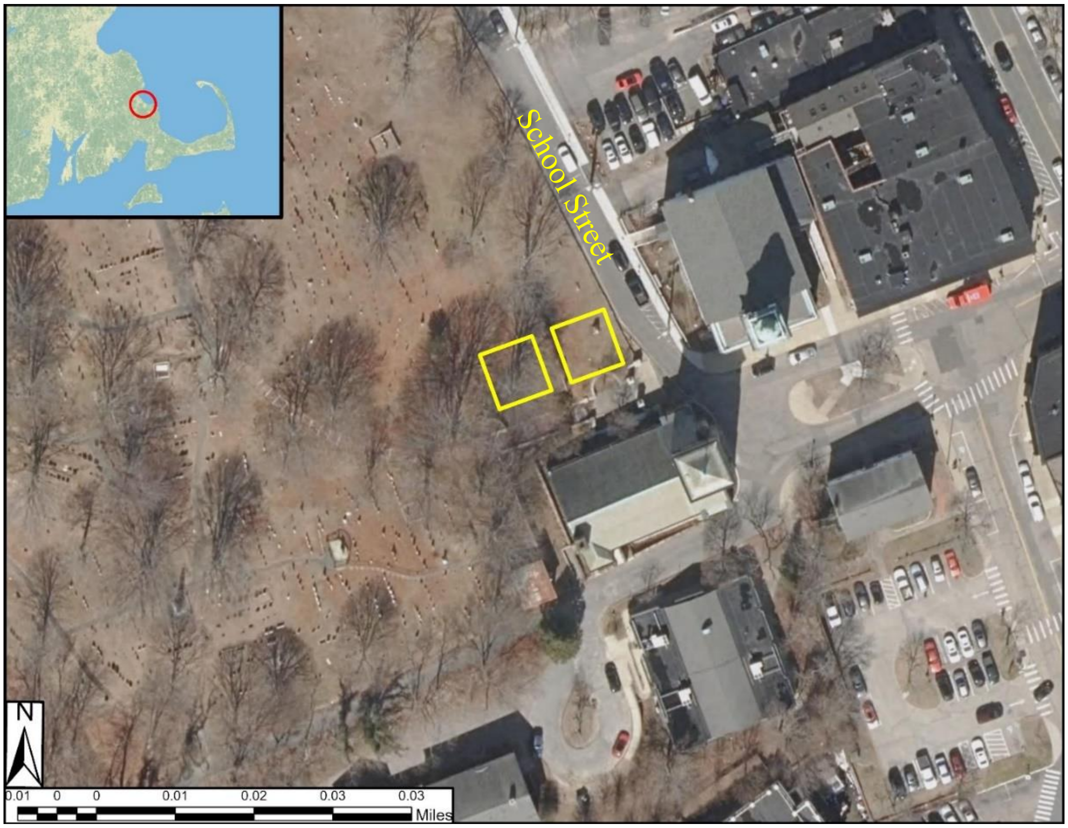


*Figure 2. Map showing the location of excavation areas on Burial Hill.*

Historically, these two families were thought to have had houses closer to the fort on top of Burial Hill (Davis 1899:289). While there is no primary documentation for the Standish's first house location, the 1630s court records suggest that the Alden house was close to the fort on the north side of the street that ran east-west through the town, which is now Leyden St (Pulsifer 1861:40). These court records state that the Alden house was on the east side of William Holmes' house which was east of the fort. William Holmes worked beside and eventually replaced Miles Standish as military captain of the colony; therefore historians have theorized that either Holmes built a house close to Standish's or, Holmes moved onto Standish's first home plot (Davis 1899:289; Pulsifer 1861:40-41; Beranek et al. 2018).

The land around Burial Hill changed hands many times throughout the 17th, 18th, and 19th centuries, whereas the core of the hill remained in the hands of the town of Plymouth during its use as an active burial ground. Starting in the mid-18th century, schools and stable buildings occupied the land at the bottom of Burial Hill that was not residential. By 1935, after four decades of consolidating parcels of land, all of Burial Hill was again owned by the town of Plymouth and is today a public historic space (Beranek et al. 2015:4-9).

As the 400th anniversary of the establishment of Plymouth Colony approaches, the University of Massachusetts Boston has conducted an archaeological survey to relocate the remains of the original plantation. The overall goal of the project is to better understand the lives of the incoming settlers as they came into contact with different landscapes and peoples already occupying the area. Among the research projects conducted around the site is an archaeological investigation that has been ongoing since 2013. This investigation, conducted by Dr. Christa Beranek and Dr. David Landon of the University of Massachusetts Boston, has uncovered two intact areas of 17th-century occupation on both sides of an 1833 crypt which lies parallel to School St. (see Figure 2). This seven-year project has uncovered features dating to pre-contact periods as well as 18th- and 19th-century occupations of the area around Burial Hill. The only excavations that are discussed in this thesis are features that were excavated between 2016-2018 and are associated with intact and disturbed 17th-century deposits (Beranek et al. 2019).

The first intact 17th-century features excavated on Burial Hill were discovered in 2016 east of the crypt. As the units in front of the crypt were expanded during 2017 and 2018, a butchered calf skeleton was uncovered, along with a possible yard space including a fence line, muck pit, a planting hole and other unidentified pit features, all dating to the 17th century. This space has been interpreted as an outside living space utilized during the 17th century that would have been associated with a residential building, which was not discovered due to the destruction of its remnants by construction during the 18th and 19th centuries (Beranek et al. 2019:25-36).

Excavations west of the crypt, also in 2016, uncovered multiple 17th-century artifacts in mixed deposits which encouraged further excavation in the surrounding area. After further excavations in 2017 and 2018, 17th-century posthole features, a steep side cut into subsoil, and intact and nonintact portions of a stone wall were discovered, along with features and artifacts indicating interior and exterior surfaces of a possibly semi-subterranean structure. These two areas of 17th-century deposits have been interpreted as some of the farthest west portions of the original settlement. It has been suggested that the excavations east and west of the crypt represent two separate residences utilized in different ways (Beranek et al. 2019:36-49). Excavation west of the crypt continued in 2019, and the interpretation of the features continues to be refined.

The archaeological contexts in these two areas that uncovered 17th-century materials and features have been analyzed and separated into "lots." These lots are used to identify and categorize sealed and mixed 17th-century deposits that are represented in multiple units of excavation. Table 1 describes the lots that produced glass tested in this thesis. Lots designated as P1 or P2 are contexts that cap sealed 17$^{th}$-century contexts, which were assigned lot names with two letters (PA, PB, PC, PI, PO, PR, PT, and PU) (Beranek et a. 2019:i, 20-27, 49-51). This thesis dates and identifies flat glass fragments found in these lots as a means to discuss the 17$^{th}$-century occupation of Burial Hill.

| ***Lot*** | ***Direction from Crypt*** | ***Lot Description*** |
|---|---|---|
| **P1** | East | A general lot of grouped contexts that are later/mixed but contain 17$^{th}$-century artifacts **east** of the crypt. |
| **P2** | West | A general lot of grouped contexts that are later/mixed but contain 17$^{th}$-century artifacts **west** of the crypt. |
| **PA** | East | Deep "muck" pit filled with organically enriched soil with low artifact content. East side truncated by construction and demolition for Town School. Contains multiple strata, possibly individual dumping episodes, interspersed with layers of cleaner sandy fill. |
| **PB** | East | Shallow trench/depression running N-S across EUs 21, 24, 27, and 34. A number of pit and post hole features were discovered under/within this depression. |
| **PC** | East | Pit to dispose of calf skeleton. Falls within the outline of the shallow N-S trench (Lot PB) in EU 21. Some artifacts/skeletal parts associated with this deeper cut excavated with cxt 305/327. |
| **PI** | East | Dark, organic deposit in the SE corner, continues beyond EU. |
| **PO** | West | Artifact bearing and cobble rich deposits at the bottom of a steep cut in EUs 29 and 33, at the east end of both units. Potential house or cellar "floor" deposits. |
| **PR** | West | A cobble feature located in eastern portion of EU 35. Cobbles fall in 1 or 2 layers and are approximately the same size. A possible cobble surface or a demolition/dumping event. Sits in a cut in the subsoil. |
| **PT** | West | A layer that seems to be exclusively 17th century inside the house cut, but above the "floor" deposits. Interpreted as a 17th century filling or slumping deposit. |
| **PU** | West | 17th-century fill deposit that contains low artifact density over cobbles in EU 35. |

*Table 1. Detailed lot descriptions assigned to contexts that are either sealed or mixed 17th-century contexts.*

Based on research presented above, it is possible the exterior space excavated east of the crypt could be associated with the Alden family. This eastern area produced 204 fragments of glass from sealed and mixed 17$^{th}$-century contexts, of which 152 were analyzed. The area west of the crypt produced 14 fragments of glass from sealed and mixed 17$^{th}$-

century contexts, of which 12 fragments were analyzed. This area west of the crypt is the interior and exterior space possibly associated with the Holmes or Standish families. To state again, because of lack of written documentation, it may never be possible to definitively associate the areas of excavation to these families. A chart depicting the excavated and tested glass from Burial Hill with the associated date range and identification of the fragments can be found in Appendix A.

The project conducted in Plymouth, MA on Burial Hill has produced so much material culture that multiple Masters' theses have resulted from this project. One such thesis is by Elizabeth Tarulis, who is studying the 17th-century ceramic assemblages from Burial Hill, the Alden First Home site, and the Allerton/Prence/Cushman site. Her thesis analyzes the formation of early English colonial trade networks by establishing an MNV for each site and identifying regions of origin for ceramic vessels. Her study also provides a preliminary comparison of resource availability in Plymouth Colony to contemporaneous English colonies (Tarulis 2020).

**Standish Family History**

The individual who possibly lived on the excavated area west of the crypt, Myles Standish, has a heavily debated past amongst colonial scholars. His place of birth is reported as either the Isle of Man or in the county of Lancashire sometime around 1584 (Davis 1908:98). Standish had fought in the Eighty Year's War and was contracted by the Plymouth Colony company specifically to be a military captain. During the first seven years of the settlement he served the colony in both aggressive militaristic skirmishes against native groups as well as in peace negotiations (Dexter 1865; Davis 1908:98, 317-319).

After the land division in 1627, Standish was allotted 100 acres in the present town of Duxbury, around 10 miles north of Burial Hill, shown in Figure 3 (Davis 1908:144, 217). It is likely that the dwelling built on this plot of land was erected sometime between the land division in 1627 and 1632, as the latter is when settlers in Duxbury were released from their weekly religious requirements. Although, 1632 is also the year when Standish, Alden and two other settlers were documented as promising to return to the town during the winter months for religious and civil duties (Davis 1908:293; Pulsifer 1861:6). This demonstrates that by 1632, these settlers would had to have built new homes on new plots of land to live on during the winter months. After Standish's death in 1656, his estate, which included the land, 44 farm animals, a dwelling house with adjacent outhouses, and all their contents, passed to his wife and eldest son. It is assumed that his wife remained living in the house until she moved to Connecticut. It is likely that their eldest son took up primary residence there, before the dwelling house burned down sometime around 1665. According to oral tradition, various Standish children and decedents lived at the farm through 1739 but none built homes on the same location as the original Standish house (Heitert 2017:22-27).


*Figure 3. Map showing the location of the Standish Site.*

Between 1739 and 1829 the property reduced in size and transferred hands many times before it was first archaeologically investigated by Reverend Benjamin Kent in 1829. This first documented intervention produced excavation notes but no surviving plans or drawings. According to Kent's list of "articles," he collected window glass, burned bottle glass, teeth, nails, and brick and mortar with burned lime. From research conducted by Kristen Heitert for purpose of nominating the excavated area to the National Register of Historic Places, the depression which Kent excavated was used as a dumping pit by locals as well as had multiple undocumented investigations before Kent's excavation (Heitert 2017:27).

After Kent's excavation, the property was bought and excavated by James Hall in 1865. Hall produced a site plan depicting two foundations at a 45 degree angle from one another on their easterly ends, shown in Figure 4. The smaller foundation to the north was drawn with three bays measuring 50 by 16 ft., and to the south, the larger foundation with four bays measures 54 by 17 ft.

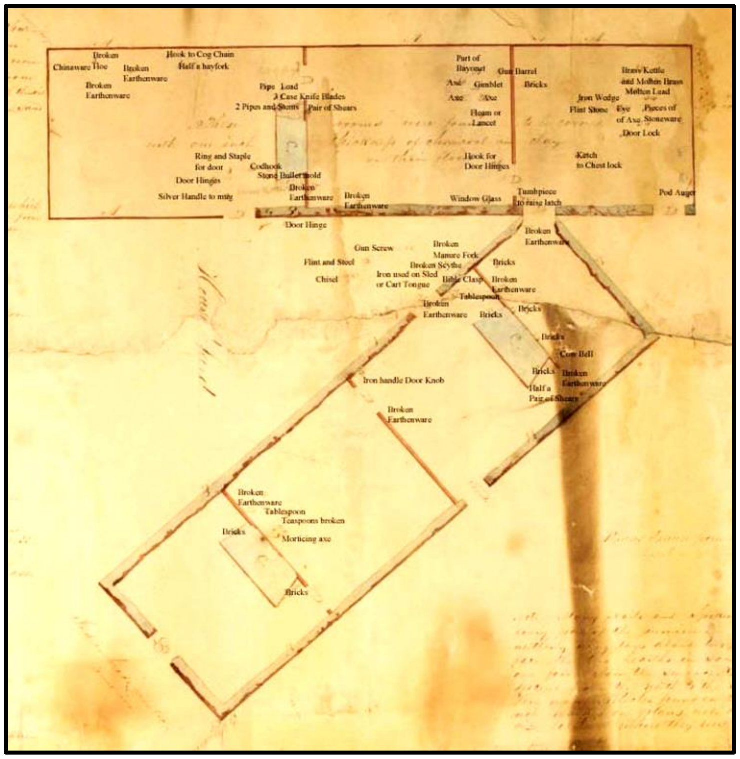


*Figure 4. Excavation plan from James Hall, dated 1865 (Heitert 2017:39).*

In the smaller foundation, a hearth was drawn on the east interior wall with a south facing doorway. The larger foundation had hearths drawn in the larger rooms with openings in the north, south and west walls (Heitert 2017:39). While this excavation was conducted before scientific archaeological standards were created, the site plan created by Hall could possibly be a good comparison to the other sites discussed in this thesis. Even though this site was disturbed by past undocumented excavation, based on the collection that remains combined with written notes and the Hall site plan, it is possible to compare this site with others archaeological sites occupied during the 17th century.

A majority of the limited artifacts that remain from the excavations at the Standish site are now housed at Pilgrim Hall Museum in Plymouth. These artifacts include nails, window glass, bricks, hinges, keys, and kettle fragments, many of which are burned. The remainder of the collection is separated between the Duxbury Rural and Historical Society, the Old Colony Society, the Rehoboth Antiquarian Society and Plimoth Plantation. The largest segment of the collection housed at Pilgrim Hall Museum was the only part of the collection that contained enough glass fragments to be tested in this study. Only 21 fragments of glass were in the Pilgrim Hall collection, all of which were able to be tested. While the numbers of glass fragments that remain from the Standish collection are quite few compared to the other two sites tested, the addition of this site adds the ability to test the validity of the method built by this project. A chart depicting the tested glass from the Standish site with their associated date ranges and identifications can be found in Appendix B.

**Alden Family History**

The area excavated on Burial Hill that is east of the crypt is near the monument marking the traditional location of the Alden property on the hill. John Alden Sr. was born around 1599 and had been a cooper in England before possibly being contracted to make barrels for the fishing venture the Plymouth Colony company was initially supposed to be.

After arriving in 1620, Alden married Priscilla Mullins who had lost her entire family during the first winter (Davis 1908:414; McCarthy 2007:38-41).

In the decade following 1627, the Alden family moved north of the original settlement to a 100 acre plot in the present town of Duxbury, where John Alden Sr. lived till his death in 1687 (Davis 1908:217; McCarthy 2007:38-41). The location of the main dwelling built on this property can be seen in Figure 5. The property and dwelling passed to the Alden's eldest son, John, who died in 1697, when he granted the entire estate to his son, also John. At the time the property, dwelling and contents passed to John Jr. (1687) it was valued at 100 pounds. Ten years later when John Jr. granted his estate to John III (1697), the value of the farm had not grown. By the time John III died in 1739 the property and its contents were valued at 2000 pounds (Mulholland 1999:243).

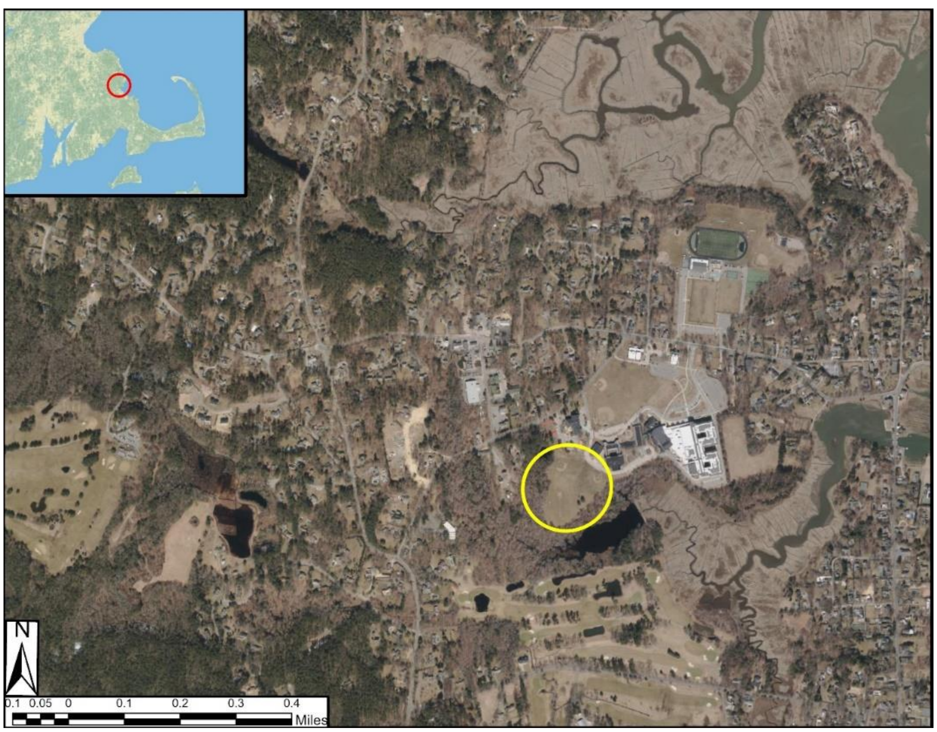


*Figure 5. Map showing the location of the Alden First Home site.*

Today, a portion of this original property is still owned by Alden decedents, a group called the Alden Kindred of America. The historic structure still standing on the property is a timber box frame in a hall and parlor style building that was occupied as a residence till at least 1896. It is known that this structure is not the first colonial dwelling built on the property, but the exact date of its initial construction is debated. Around 1000 yards to the east of this standing building is the location of the Alden First Home site, which was excavated by Roland Robbins in 1960 (McCarthy 2007:12-14). For the remainder of this thesis, the Alden First Home site is referred to as the Alden site.

There is a reference to another family home built sometime in the first half of the 17th century besides the one excavated by Robbins and the currently standing structure (Winsor 1849:57). This reference is unsubstantiated by other written documentation or by archaeological evidence and is not discussed in the remainder of this thesis. A debate that is pertinent to this thesis is the time frame of destruction of the original home excavated by Robbins and the construction of the currently standing structure.

The dwelling excavated by Robbins has been determined to be the home built by the Alden's between 1627 and 1632 (see discussion in the Myles Standish History subsection). There is an oral tradition that suggests that this excavated structure and the one currently standing were both built and lived in by John Sr., Priscilla, and their family (McCarthy 2007:51-55). However, the following research argues that the excavated structure likely rotted in place, and the current standing structure was built around 1703 by John III.

The presentation of values assigned during probate inventory of the Alden property, discussed above, demonstrates that only during the thirty years the property is owned by John

III does the value of the estate increase. This probate inventory analysis was initially presented by Mitchell Mulholland of the University of Massachusetts Amherst, who conducted an archaeological excavation and documentary analysis of the Alden properties in the 1990s. The excavation was conducted around the standing structure and produced an artifact assemblage indicative of an occupation starting after 1700. This conclusion was an echo of an architectural analysis completed by Abbott Lowell Cummings in the 1970s, who classified the standing structure to date to around 1700, but Cummings suggested further analysis was needed for a more conclusive answer (Mulholland 1999: 243-248).

This study was assessed further by Thomas McCarthy when he submitted an application for a nomination to the National Register of Historic Places for the excavated dwelling and standing structure. McCarthy discusses the important dendrochronological study completed by Nicole Davi and Paul Krusic of the Tree Ring Laboratory at Columbia University. This study concluded that the oldest timber in the standing structure was felled in either 1636 or 1698, with all of the other timbers felled after 1698. None of the timbers tested were large enough to produce concretely conclusive dates (McCarthy 2007:9-10).

Caroline Gardiner's Master's thesis adds an important conclusion based on previous research and an expanded ceramic analysis. Gardiner suggests that the original cellar hole was likely not used extensively for post occupation dumping and it is possible the structure rotted in place in the late 17$^{th}$ century (Gardiner 2017:13-14). Based on the archaeological, architectural, dendrochronological, and documentary research conducted on the standing structure it is very likely that the current standing structure was built sometime after 1700.

The destruction of the dwelling excavated by Robbins is more fully explored in later chapters of this thesis.

The Robbins excavation uncovered a 38 by 10.5 foot stone foundation, a possible brick chimney and a stone lined cellar, shown in Figure 6. Robbins maintained horizontal control during excavation but did not maintain vertical control except in the cellar hole (Robbins 1969). Based on research completed by Gardiner, this building was likely a tripartite house based on artifact distributions calculated using spatial analysis. These distributions also showed a possible window on the eastern gable end of the house, which was a common window location in colonial houses dating to the 17th century (Robbins 1969:45; Gardiner 2017: 92-93).

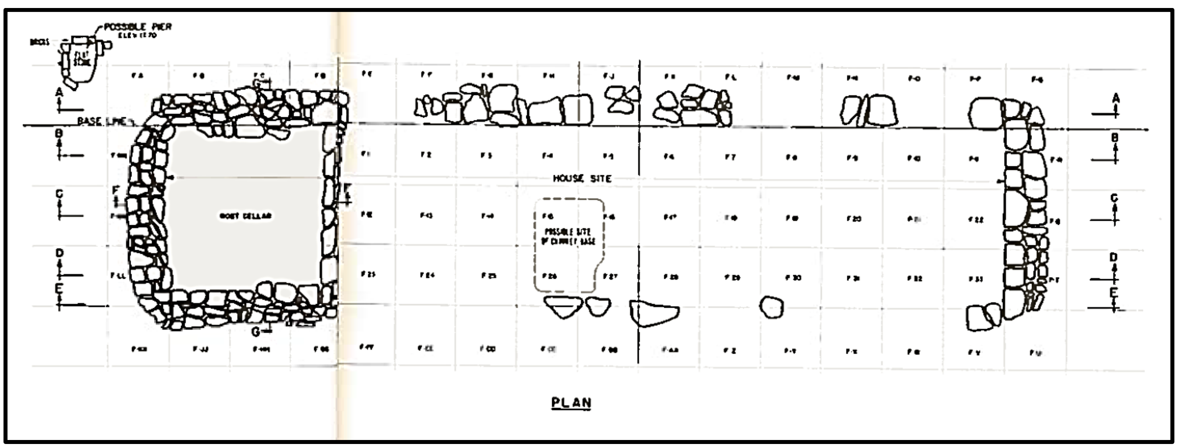


*Figure 6. Plan map of Robbins 1960 excavation.*

The Robbins excavation uncovered over 10,000 artifacts, including almost 2000 artifacts determined by Robbins to be Native American in origin. The glass from the initial Robbins excavation was identified as window or bottle by Robbins and his crew. These identified artifacts included over 150 glass bottle fragments and more than 1400 flat glass fragments. The bottle glass consisted mostly of English black bottles, which became popular during the mid-17th century (Godfrey 1975:150, Jones 1986:9). The case bottle fragments in the collection were either identified simply as curved bottle glass or misidentified as window glass. After this collection was partially cataloged by Mulholland's students in the 1990s, the identifications of glass fragments was expanded to include window, case, and bottle glass. From the cataloging conducted in the 1990s, 12 case bottles, and 1,521 fragments of window glass were identified. Of those fragments considered relevant to this thesis, 764 were able to be tested using the pXRF method. A chart with the excavated and tested glass and their resulting identification and date ranges can be found in Appendix C.

**History of Glass Production**

This section explores the history of glass production in England and the major influences of glass production which migrated in from mainland Europe. This history is extremely important to understand because the changes in the chemical composition of glass over time can enable identification and dating of glass fragments and help place these artifacts in a larger cultural context.

During the 16th century, large groups of people were moving to England seeking economic prosperity from growing English industries, such as iron and glass manufacturing (Godfrey 1975:10-30). As continental Europeans moved to England, they brought their traditional production styles with them. These incoming European craftsmen were the major catalyst for how English industries changed starting in the late 16th century, especially in glass manufacturing.

Tutton et al. (2015) write that the chemical composition of glass is comparable to a fingerprint, with mass produced items that look visually similar but under microscopic inspection are completely distinct. The composition of glass products can vary greatly due to variation in raw materials, fuel source, and types of heating vessels used over time and across the industry. As glass can have such a wide range of elemental compositions, there is a substantial amount of information that can be learned from identifying unique elemental signatures in glass fragments found at archaeological sites.

Glass is created by heating and combining a silica component (sand) and an alkali component or flux that lowers the melting temperature of an overall silica melt. Sand is typically used as the chief component for glass making as it is mostly silica (quartz), but its content can be variable based on the vegetation, bedrock, and geologic region where the sand is formed. This causes other contaminates, such as heavy iron content that creates a green color in glass, to alter the final product (Douglas et al. 1972). The typical melting point of pure quartz is 1710˚C, but to make a product that lacks impurities, the temperature of a furnace needs to be around 2200˚C. Once the alkali flux is added, typically from woodland or marine plant ashes, the melting temperature of a silica melt can lower to around 800˚C (Douglas et al. 1972; Godfrey 1975:3; Tutton et. al 2015). These fluxes are important because their chemical content enables a large amount of glass dating and identification.

*Glass in Europe and England*

In England, after the fall of the Roman Empire, glass production was largely abandoned, except in Chiddingfold, in Surry County in southeastern England (Godfrey 1975:9). During the 13th and 14th centuries, the most typical window and vessel glass produced in England was forest ash (potassium-ash or potash from oak) glass with a high potassium, manganese, and phosphorus content (Godfrey 1975:9-12; Dungworth 2012:33-38).

This time also saw the expansion of Venice as a well-guarded glass production hub and port. Glass makers in Venice were experimenting with different production methods and materials, such as the effects of decolorizers like manganese and lead oxides. Many craftsmen fled Italy during the 16th century and spread their production secrets around Europe. Venice diminished as a glass production hub by the end of the 17th century as England began to export cheaper versions of the crystal glass that Venice was known for (Douglas et al. 1972; Dungworth 2006:453-457). A woodcut dating to the 16th century that depicts Venetian glass production, brought to England during the late 16th century, can be seen in Figure 7.

*Figure 7. A typical 16th-century Venetian style glass house as portrayed in Agricola's De Re Metallica (Godfrey 1975:146).*

During the 14th and 16th centuries innovations in glass making began to develop in France and Bohemia. Glass makers in Normandy, during the 14th century, expanded the crown method of window glass production by taking larger gathers of molten glass and spinning them to create 24 in. diameter discs. In the same century, glass makers in Bohemia, and Lorraine were establishing the broad glass method, which is when a large gather of molten glass is blown into a cylinder and then cut longitudinally and laid down to flatten. These glass making traditions both used forest ash (potash). In central Europe beech wood was the popular source of potash that produced green vessels and window glass (Godfrey 1975:6-7; Dungworth 2012a:26).

*Immigrant Glassmakers in England*

After the Reformation, during the initial growth of the English empire, continental Europeans were both fleeing and being brought to England for the economic gain of the host country. The first noted emigration of glass makers from mainland Europe to England was in 1549, when cristallo glass makers from Murano, Italy moved to London to profit from the lack of cristallo glass production in the country. This glass was made using lead, which according to Godfrey (1975:161), would not only increase the refractive index for glass creating a clearer product, but also had properties which enabled that product to be stronger. The use of lead in glass production changed throughout the $17^{th}$ century in England with a dramatic increase after the English crystal glass market expanded aggressively in 1674 (Dungworth 2006:453-457).

The second and more notable emigration of glass makers started in 1567 when window and green glass makers from Normandy and Lorraine moved to England in large groups to seek better economic prospects from the industrial monopolies established during Queen Elizabeth I's reign. The first window and green glass patents granted in England during the end of the $16^{th}$ century required incoming craftsmen to train Englishmen as a way to create a sustainable glass industry there. These patents also detailed the prohibition of importing foreign glass to England (Godfrey 1975:21). The glass makers were producing High Lime-Low Alkali (HLLA) window glass and green glass vessels (drinking vessels, urinalia, case bottles, etc.), using wood ash from oak and birch or small forest bushes, such as thistle and brambles (Dungworth 2012a:33-35). Typical case bottle and window glass examples from the 16th and 17th centuries can be seen in Figure 8.

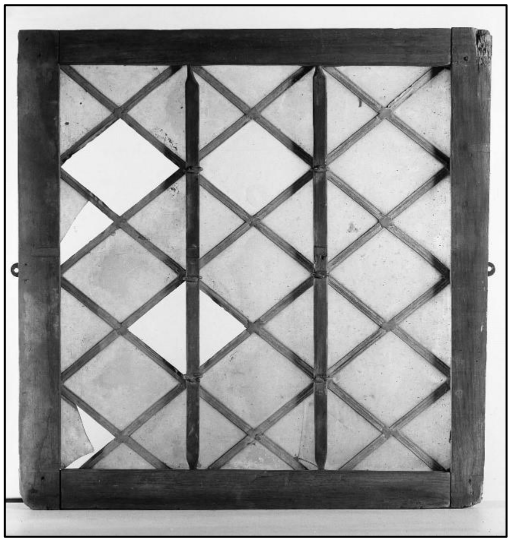

*Figure 8. Left: 17th-century casement window. Right: Reproduction 17th-century case bottles.*

During the following three decades, glass makers from Normandy established furnaces in the Weald and the Lorraine glass makers moved farther north to the forest of Dean and Staffordshire. These glass makers were forced to move throughout England because of the rising cost of raw materials (mostly wood for fuel), the high cost of moving whole families to another country, and the large expense of shipping a fragile product around England and to other countries. With high overhead, and as the cost of raw materials increased, manufactures required a higher production output to equalize the input cost of production, but with more product for sale, the cost of glass fell (Godfrey 1975:27; Dungworth 2012b:14-15). As glass products flooded the market, there was a notable increase in window glass utilization among the lower classes going into the 17th century (Tutton et al. 2011).

Due to this increase of glass product in the English market, there was a matching increase in use of raw materials. Therefore, at the turn of the $17^{th}$ century, there was growing concern for how much rising English industries were depleting wood sources. This concern grew to full public outcries for the prohibition of wood use by industrial producers. Between 1607 and 1615 the prohibition on use of wood for fuel grew from laws barring industrial use of wood fuel to a total ban of burning wood as fuel for all citizens (Godfrey 1975:38).

After the introduction of these laws, a rich merchant, Robert Mansell bought patents and gained monopolies over all glass production in England between 1615 till 1642 (Douglas et al. 1972, Godfrey 1975:75; Tutton et al. 2011). As Mansell gained power in the glass industry, he combated mounting regulations by moving glass houses closer to coal (new fuel source) resources farther north in England as well as to the coast near water ways to increase profits (Godfrey 1975:75-77).

Once glass houses became more established in new locations, the next huge innovation in the glass industry was the use of kelp as a flux. This change of flux material was possibly an attempt to decrease the cost of importing other raw materials or to decrease the overuse of other flux materials found in England. According to the Oxford English Dictionary, kelp ash is first referenced in 1663 for the use of dying cloth (OED 2020). The first notation of kelp being used in glass production as a flux is in 1662 in *The Art of Glass* (Merrat 1662). Kelp has both substantial potassium and sodium content that would decrease the temperature of an overall glass melt. Kelp also contains a very high strontium content, which is reflected as a trace impurity in the final glass product. The glass produced during this time is referred to as Mixed Alkali glass as multiple alkali types are found in these products (Dungworth 2013:120). It is also important to note that the transfer to kelp ash flux use around 1660 was not a universal transfer all at once. Glass houses that produced vessel glass continued to use fluxes other than kelp through the 18th century (Dungworth 2013:121). However, kelp ash use in window glass production completely took over as the primary flux around 1700 (Dungworth 2011:33-40; Dungworth 2013:119-222).

### *Colonial Glass Consumption*

While the glass market was unstable in the early 17th century, English investors sought to establish glass houses in English colonies across the world as a way to feed the English market with cheaper produced glass. However, glass production was very difficult to establish in the American colonies due to the high cost of bringing experienced craftsmen from Europe and the ease of access to cheaper glass products coming to England illegally from mainland Europe (Wilson 1972:6-9). Four substantial attempts to establish glass production in the colonies are documented between 1639 and 1739: in Salem, MA in 1639, near Philadelphia in 1682, and twice near present day New York City sometime after 1670 (Scharfenberger 2004:59-61). None of these glass houses remained in production for very long and typically only supplied limited areas around the production house. Therefore, in the early years of these colonies the glass that populated domestic homes was chiefly coming from Europe.

Multiple historians and archaeologists have argued that most, if not all, of the glass in the English colonies before the American revolution was coming from England rather than other glass producing centers throughout continental Europe. This conclusion was reached due to the high taxes and tariffs placed on glass imported to the colonies from countries other than England (Wilson 1972; Davis 1949:22-25; Scharfenberger 2004:61). These regulations were formalized through the 1651 Navigation Act, which was enacted after the end of the Eighty Years War and the English Civil War. The end of these wars brought about a need for more formalized ruling on international trade (Pestana 2004:120). Before the English Civil War and the first Navigation Act, the regulations banning importation of glass to the colonies were through patents and monopolies held by Mansell (Godfrey 1975:75-80).

While the conclusions about importation of glass are based on regulations placed in England, there is a high likelihood of at least some glass being brought to the colonies from other European countries during the first three quarters of the 17$^{th}$ century. Before the end of the 17$^{th}$ century, English colonists moving to New England were not the only Europeans moving through the area. A Dutch agent of the Dutch West India Company even visited Plymouth Colony in 1626 (James 1963:63-65). Therefore, as groups of Europeans were interacting and trading together, it is very likely that during the 17$^{th}$ century, even after the Navigation Acts, glass being utilized at New England sites was not only from England. Comparatively, this trading can be seen in the evidence of ceramics found at 17$^{th}$-century New England sites from Italy, Portugal, and Germany (Beaudry et al. 2003:159-160; Gardiner 2017:18-23; Tarulis 2020).

Colonists settled in New England would often write back to England pleading that incoming colonists should not forget glass amongst their furnishings to be brought to New England. This adds a level of complexity to an already complex story of glass in the colonies.

Based on what has been discussed above, it would be a very large project to tease out the original production locality of the flat glass from archaeological sites in New England. This is because more extensive background research, pXRF and likely isotope analysis would need to be conducted to determine the typical characteristics of each flat glass product from the major European production centers. Studying the composition of flat glass to try to identify production localities based on the different types of fluxes and raw materials used is potentially an interesting project but outside the scope of this thesis.

Conversely, with the understanding of lead and kelp ash use in glass production as presented above, there is still a substantial amount that can be learned from the flat glass at archaeologist sites in New England. As the English market was flooded with cheap glass products in the first half of the 17$^{th}$ century and colonists were likely bringing at least some glass products with them as well as purchasing English glass products once arriving, it is likely that most of the flat glass at the sites studied in this thesis were made in England. Therefore, the composition of strontium and elemental lead in flat glass is still a substantial attribute that can be utilized in analysis at these colonial sites.

Based on the history detailed above, elemental attributes of glass can be studied to aid in not only dating glass but also identifying highly fragmented glass artifacts. The major attributes focused on in the remainder of this thesis are the variations in strontium values from the flux being used and the variations in lead composition discovered in specific types of glass vessels. The strontium composition variation is caused by trace impurities in the flux used in glass production. Conversely, the lead composition in glass products are due to the addition of lead to glass melts for use as a decolorizer, strengthener, or flux. The following section explores how kelp was identified as the origin of the high strontium content in glass produced in England during the 17th and 18th centuries.

### Summary of X-Ray Fluorescence and Dating Analysis of Window Glass

Flat glass has been studied both by using X-Ray Fluorescence (XRF) as well as measuring the thickness of flat glass artifacts. The method of measuring the thickness of window glass has been proven useful by multiple archaeologists, but this method is regionally specific and is most useful in dating 19th-century glass (Weiland 2009:29-30). While XRF has many applications and has been used to date window glass, this technology has also been used to date and identify glass tablewares and glass beads from all over the world dating to *all* periods of glass production (Goudge 2014; Gronniger 2016; Fitzpatrick 2017; McCabe 2019).

Past work conducted using XRF analysis that pertains to this thesis was conducted by Dr. David Dungworth, who has published extensively on historic glass. Specifically, Dungworth has utilized XRF technology to develop a timeline of chemical compositions of English window glass. This timeline was produced by determining the composition of *in situ* window glass as well as archaeological glass fragments from glass production sites. The seminal research underlying thesis comes from Dungworth's publications: "Kelp in Historic Glass: the application of Strontium isotope analysis" (Dungworth et. al 2009); "Historic Windows: investigation of composition groups with nondestructive pXRF" (Dungworth 2012a); "Historic Window Glass: the use of chemical analysis to date manufacture"

(Dungworth 2012b); and “Innovations in the 17$^{th}$ -century Glass Industry: the introduction of kelp (seaweed) ash in Britain” (Dungworth 2013).

The first publication referenced above, “Kelp in Historic Glass,” (2009) introduces and analyzes the usefulness of strontium in dating geologic structures, analyzing skeletal material, and dating glass. For glass, Dungworth et. al compared strontium isotope ratios found in glass produced after 1660 to the isotope ratios of modern kelp. While it was documented in the 17$^{th}$ and 18$^{th}$ centuries that kelp was used as a flux in glass making starting around 1660, there had never before been a confirmation that the kelp flux was the cause of high strontium content in this type of glass. The authors compared strontium isotope ratios of high strontium glass fragments dating to the 17$^{th}$ century to the strontium isotope ratios of modern kelp or seaweed. As these ratios matched, they were further compared to the strontium ratios of glass made with other sea plant fluxes, such as natron, which did not match. Since the strontium isotopes of modern seaweed and high strontium glass matched, the authors were able to conclude that the high strontium content in this glass was due to the kelp flux used during production (Dungworth et al. 2009). Dungworth et al. (2009) also conclude that modern and historic kelp are isotopically similar. This publication is the origin of the method that this thesis used to build a technique for dating glass based on its strontium content.

Dungworth’s “Historic Windows: Investigation of Composition groups of non-destructive pXRF” (2012a) compared two phases of a project to quantify the differences in reliability of laboratory based XRF testing and pXRF units. The major conclusions from this article are that the thickness of samples required for the XRF to produce fully quantitative readings of a material's elemental composition is a minimum of 2 mm and that lighter elements including Na and Si were not read well by a pXRF. In addition, this article concluded that the pXRF read heavier elements (Ti, Mn, Fe, As, Rb, Sr, Zr, Ba, and Pb) with great accuracy, and, very importantly, that heavier elements are not significantly affected by glass corrosion. These conclusions were reached by comparing corroded glass tested with both laboratory techniques and pXRF units, at two sites with both archaeological samples and *in situ* glass (Dungworth 2012a). This publication is important to this thesis as it outlines the usefulness and limitations of a pXRF technology with glass analysis.

"Historic Window Glass: The Use of Chemical Analysis to Date Manufacture" (2012b) outlines the evolution of glass composition that was produced in England from 1300 to the present. Dungworth emphasizes the importance of understanding window glass in historic buildings both figuratively and literally as windows aid in conceptualizing physical historic viewsheds and have been used as a proxy to understand evolving architectural norms in England. A timeline of glass production was established through XRF testing conducted on archaeological remains of glass from production sites, residential locations, and ecclesiastical sites then compared to *in situ* glass present in standing structures at those sites. By grouping elemental compositions of glass in association with the date range of the site from which the glass was sampled, a timeline was established (Dungworth 2012b).

The final publication "Innovations in 17$^{th}$-Century Glass" (2013) presented an in-depth timeline of 17$^{th}$-century English glass as raw material usage changed throughout the century. In this publication, Dungworth presents that the complete adoption of kelp as a flux did not happen immediately as glass houses went through a gradual transition during the 17$^{th}$

century, as access to raw materials changed. This article also discusses the melding of multiple types of glass production as continental Europeans moved to England, beginning in the late $16^{th}$ century (Dungworth 2013).

This background of Dungworth's work on XRF analysis establishes the analytical basis for this thesis. The following chapter applies these studies to build a method both for dating flat glass around 1660 and also for identifying flat glass as window glass or case bottle glass from the $17^{th}$ century.

# CHAPTER 3

# METHODS

This project seeks to create a methodology for identifying and dating flat glass from 17$^{th}$-century sites. This method employs X-Ray Fluorescence to assess strontium and lead compositions using Net Peak Area (NPA) from glass samples at three archaeological sites in Plymouth colony. The first portion of this method was extrapolated from David Dungworth's work dating window glass and has been used in this thesis to identify relative high strontium content of flat glass to date glass fragments to production after 1660 and date relative low strontium content glass to before 1700. The second portion of this method, developed during the data collection of this thesis, is that flat glass fragments with relatively low strontium content can be identified as case bottle glass, if those fragments have relatively high lead content versus window glass fragments, which typically have relatively low lead content. For this XRF study, the Bruker Tracer III-SD spectrometer was used for measuring elemental composition of glass fragments. This spectrometer is a portable, handheld unit.

**X-Ray Fluorescence Technology**

X-Ray Fluorescence (XRF) is an analytical technique to measure elemental composition within an object. An XRF spectrometer shoots x-rays into an object which temporarily excites the electrons orbiting in the atoms within the object. After x-rays hit the object, photons are emitted by the electrons of each element from electron shells K, L, and M. The energy produced when these electrons return to a stable lower energy state is characteristic of specific elements. The signal emitted by the de-energized electrons is processed and an energy spectrum graph, shown in Figure 9, is produced. The x-axis on this graph displays the descriptive energy emitted by the photons and received by the pXRF detector, which are measured in kilovolts. This axis is divided into 150 volt increments called channels. The y-axis of this graph records the number of photons that hit the pXRF detector, which causes a momentary pulse of electricity used for measuring the elemental concentration within the object. Each peak in the graph represents a certain element's electron shell energy emission (Shugar and Mass 2012).

The spectra information that is produced from the spectrometer is affected by the configuration of the unit and the computer software that processes the data. Therefore, it is necessary to understand the effects of the unit's configuration on the processed data. Shown in Figure 9 are three important characteristics of spectral data that need to be acknowledged. The features marked 1 are primary and secondary peaks. These peaks are associated with the same element but are characteristic of different photon energy levels. The primary peak represents alpha energy and the secondary peak represents beta energy, which are different types of radiation energies that are produced from the electrons movement. The feature marked 2 is backscatter. This scatter is produced when X-rays moving from the object back to the detector are mixed with excess x-ray energy that was initially produced from the spectrometer. The way to reduce this scatter is by adding a filter to the unit. Filters cut out a specific range of elemental energies that are read by the unit, which enables the unit to refine the produced reading to a specific range of elements.

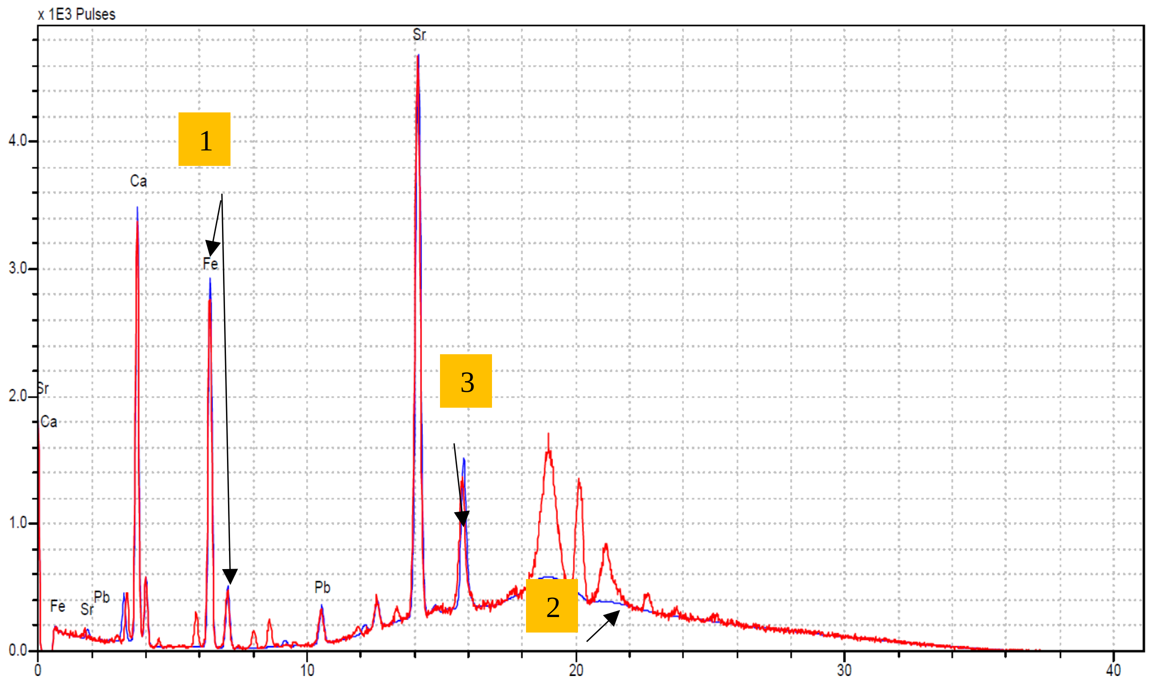


*Figure 9. A spectral graph showing (1) Primary and Secondary Peaks; (2) Backscatter; and (3) Mixed Peaks.*

The feature marked 3 is a mixed peak. This feature points to a secondary peak within another. As discussed previously, when the X-rays reach the atoms within the object, multiple rings of the atom are affected and lose electrons. The K shell, which is the ring closest to the nucleus of the atom that loses electrons and produces the most energy, is usually the largest peak that is shown in the spectra graph for that element. The M and L shells emit less energy than the K shell, and this energy is characteristically different, which is therefore represented in different locations on the spectra graph. Sometimes these M and L readings overlap with other element's K readings producing this secondary hump (Shugar and Mass 2012). Any possible misidentification of elements caused by mixed peaks can be alleviated by the addition of a filter as well as close examination of primary and secondary peaks.

A yellow filter (0.001'' Ti, 0.012'' Al) was used for this study to remove potentially overlapping signals from elements lighter than calcium. The range this filter highlights is from titanium to gold K shell energies and tungsten to bismuth L shell energies. A setting of 40 kilovolts was used to increase the sensitivity to elements with x-ray energies ranging from 12 to 40 kilovolts (Kaiser 2008). No vacuum was used in this study.

Strontium was semi-quantitatively measured using the pXRF to determine general high and low content within glass samples. Based on Dungworth's work, the high strontium groupings can be concluded to have been produced after 1660 (Dungworth 2013). The lead was discovered to be significant during the course of this study and was also semi-quantitatively measured to determine if it is statistically significant in identifying case bottle and window glass fragments.

## Corrosion and Leaching

There are some possible limitations to testing glass using pXRF based on the levelness of sample surfaces, the corrosion of the sample, and any superficial adherents to the glass samples. The pXRF is a very sensitive tool and any slight variation in the surface of the object can cause the data to be skewed. This discussion describes environmental factors that can skew the data as well as chemical and elemental properties of glass that substantiate this study's validity.

For XRF testing, it is a widely known attribute that elements are scanned by the spectrometer at different depths within the artifact (Dungworth 2012a; Kaiser and Shugar 2012; Adlington and Freestone 2017). The depth from which energies are measured is logarithmically reliant on the characteristic energy that is emitted during the electron's movement process (Kaiser and Shugar 2012). As Dungworth, and Adlington and Freestone present in their respective papers (2012a; 2017), strontium and lead are relatively heavy as compared to elements such as calcium (Ca) or iron (Fe) and are "read" deeper within glass. Both of these papers present that the depth strontium and lead are read is considerably deep within the artifact (more than 700 ųm). Therefore, glass samples were only tested if they were thicker than 2 millimeters. There are a small number of samples that were not tested as they were too thin, although a significant number of fragments were not tested due to the level of corrosion of the sample.

The environment that the sample is in can also affect the readings that are produced by the spectrometer. These environmental issues are mostly caused by superficial adherents to the surface of the sample and leaching caused by the depositional environment of the sample. According to Stephen Koob, the head conservator at the Corning Glass Museum, strontium is likely to be unaffected by chemical alterations from the soil, unlike Ca (calcium) or Fe (iron) which are heavily affected by the content of soil. (Personal Communication, via

Dennis Piechota, May 3rd, 2018). Although, Ogburn et al. (2012) presents that lead is an element that is susceptible to leaching, the authors discuss that it is likely only to adhere to artifacts or substances that are porous in nature and/or that are heavily corroded. Therefore, strontium content is less likely to be affected by soil leaching, but lead leaching could cause some outliers in this thesis data if the fragment is overly corroded or if lead objects are adhered to the artifact. Since lead came was common in glass windows of the period the potential for increased lead levels from associated window cames was taken into consideration in this study.

Adlington and Freestone discuss the process of leaching elements and substantiate their tests by focusing on elements that are heavier and therefore are being read deeper within the glass, as is done in this thesis. Adlington and Freestone (2017) also note that corroded layers were removed during conservation, which aids in the accuracy of their readings. This thesis's purpose is to develop a non-destructive method with minimal alteration to glass samples, so any removal of corroded layers of glass fragments was dismissed. Due to this, glass samples that are heavily corroded over a majority of their surface (>90%) to the point of delamination (flaking), were recorded, but not tested. Table 2 details the number of fragments which were ineligible and eligible for pXRF testing based on their level of thickness and corrosion from each of the three sites.

| | *Eligible* | *Ineligible* | *Total* |
|---|---|---|---|
| **Burial Hill Site** | 164 | 54 | 218 |
| **Alden Site** | 764 | 769 | 1533 |
| **Standish Site** | 21 | 0 | 21 |

*Table 2. Total flat glass fragments determined both eligible and ineligible for testing, based on their physical attributes and level of corrosion, from the three sites studied in this thesis.*

Table 2 shows different proportions of glass samples that were produced from excavation compared to the samples that were able to be tested between the three sites. This difference in proportions is possibly because of varying depositional conditions between sites. Differences in site formation processes and soil composition could have caused varying proportions of corroded glass fragments uncovered at the sites. Soil composition can fluctuate based on post occupational dumping, which could add contaminates to the soil, or more likely, the typical nature of the soils at different sites based on geographic location and natural topography (Adlington and Freestone 2017). The difference in corrosion proportions is also likely due to the way the collections were maintained after excavation. A more extensive study of the corrosive nature of specific soils and the negative effects of poor storage on archaeological collections based on the data collected in this thesis would be worth exploring in the future.

A typical glass fragment that was not tested is shown in Figure 10. To alleviate further concerns of false readings, caused by non-level surfaces, adherents, or leaching, control tests were conducted to determine if these issues would statistically affect the values produced during the course of this study.

*Figure 10. Example of corroded glass samples that were not tested in this study.*

## Control Tests

### *Abrasion*

The first test was to determine if abrading all of the samples to create a level surface was needed for this method. There were six glass samples tested that had no visible corrosion (dulling, iridescence, pitting or flaking). These samples were tested twice (before and after polishing) to measure if abrasion would smooth the surface enough to warrant abrading all the glass fragments included in this study.

The samples were tested after being washed with distilled water to remove any superficial adherents and then scanned using the pXRF for 60 seconds. After the first scan, each sample was abraded using 8-micron cerium oxide sandpaper, washed with distilled water, and then tested again for 60 seconds in the same location as the first test. The results of this test are shown in Table 3, and Figures 11 and 12. Table 3 details the result of each test, and the mean and standard deviation for the two readings from the six tests for the lead and strontium content, before and after abrasion. Figures 11 and 12 show the standard deviation of each sample tested before and after abrasion in a box and whisker plot for lead and strontium, respectively. A standard deviation is a measure of the variation of a dataset's values relative to the mean of that dataset. This test shows that the variation of lead counts is between 50 and 300 counts, and a variation of 150 to 800 counts for strontium. Due to the typical range in channel counts (units along the x-axis of Figure 9) for the two elements used in this study (lead 700-20,000; strontium 9,000-200,000), this variation in values is not substantial enough to argue for abrading every sample.

**Descriptive Statistics**

| *Sample* | | *Test 1* | *Test 2* | *Mean* | *Std. Deviation* |
|---|---|---|---|---|---|
| A | **Lead** | 7993.00 | 7918.00 | 7955.5000 | 53.03301 |
| | **Strontium** | 21056.00 | 21294.00 | 21175.0000 | 168.29141 |
| B | **Lead** | 7845.00 | 8213.00 | 8029.0000 | 260.21530 |
| | **Strontium** | 21174.00 | 20567.00 | 20870.5000 | 429.21382 |
| C | **Lead** | 8380.00 | 7931.00 | 8155.5000 | 317.49094 |
| | **Strontium** | 20795.00 | 21064.00 | 20929.5000 | 190.21172 |
| D | **Lead** | 7638.00 | 8051.00 | 7844.5000 | 292.03510 |
| | **Strontium** | 21622.00 | 20420.00 | 21021.0000 | 849.94235 |
| E | **Lead** | 7855.00 | 8287.00 | 8071.0000 | 305.47013 |
| | **Strontium** | 21170.00 | 22200.00 | 21685.0000 | 728.31998 |
| F | **Lead** | 8135.00 | 8068.00 | 8101.5000 | 47.37615 |
| | **Strontium** | 20847.00 | 21227.00 | 21037.0000 | 268.70058 |

*Table 3. Descriptive statistics for the two tests of the glass samples, once before polishing and once after polishing.*

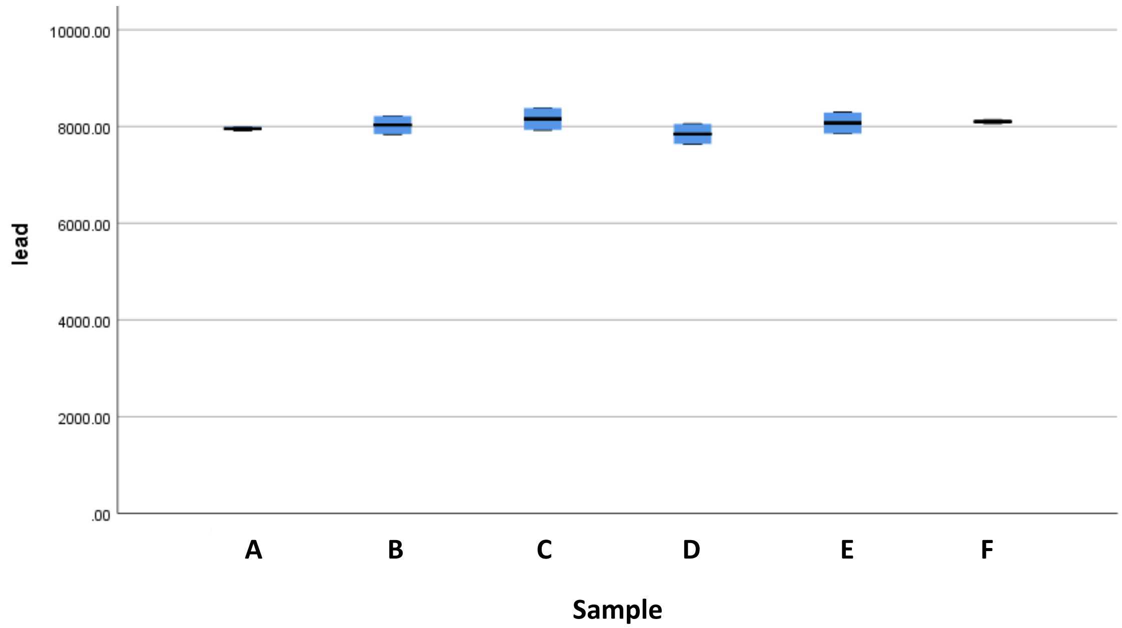


*Figure 11. Box Plot showing the lead count variation from the 6 samples tested in the abrasion test.*

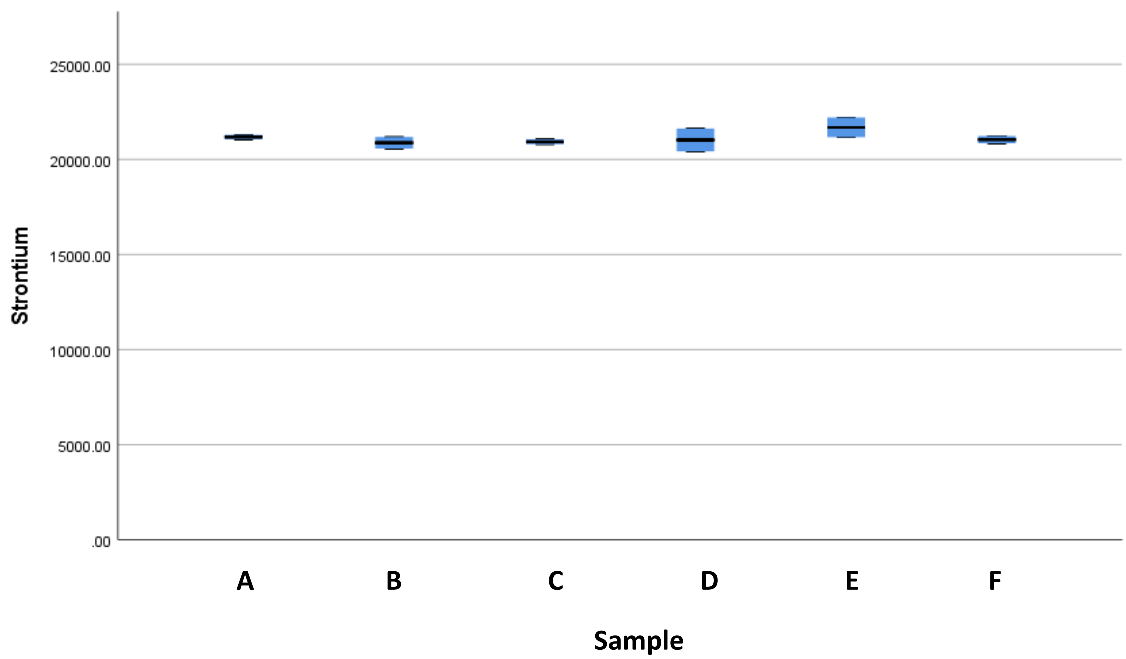


*Figure 12. Box Plot showing the strontium count variation from the 6 samples tested in the abrasion test.*

*Calibration and Net Peak Area Control Tests*

XRF studies typically use spectrometer calibrations to quantify the elemental composition of the samples being tested (Dungworth 2012a; Goudge 2014; Gronniger 2016; Fitzpatrick 2017; McCabe 2019). For the method built in this thesis, instead of having fully quantifiable composition, general groupings of elemental composition of strontium and lead is established to group glass samples into artifact classes. These artifact classes encompass use types (window glass or case bottle glass), and production age range (produced after 1660 or produced before 1700). Due to this study not seeking to create a full elemental profile for the glass samples, a true calibration was not developed for this thesis.

The method used by this study to analyze the raw spectra results is Net Peak Area (NPS). As presented by Forster et al. (2010), Grave et al. (2012), and Bissett et al. (2016), the NPA of pXRF tests creates a relative spectrum of raw channel counts for an artifact class that replaces the fully quantitative values produced from a true calibration. NPA provides a semi-quantitative analysis based on the relative abundance of the elements compared. In short, an NPA uses the average counts for each element produced from the spectrometer to create a relative index of numbers that can be compared. This enables a comparison of samples without a true calibration of data.

A final control test was conducted to quantify if testing samples more than once would be required for this method. Recent XRF studies that have substantiated and utilized NPA tested samples multiple times in multiple locations. Forster et al. (2010), Grave et al. (2012), and Bissett et al. (2016) all analyzed non-homogenous samples using NPA (lithics, shells, and ceramics), and their respective articles discussed testing the samples multiple times and averaging the raw data. However, as Adlington and Freestone (2017) present in their article, glass is homogenous enough to be sufficiently tested a single time with a pXRF unit. Since glass is much more homogenous then the artifacts being tested by Forster et al. (2010), Grave et al. (2012), and Bissett et al. (2016), it was proposed to test the glass samples only once.

Knowing these points, a control test was completed to understand the statistical significance of testing glass multiple times in multiple locations. For this test, two sets of five glass fragments were analyzed to quantify the variation of raw counts caused by testing glass samples in multiple locations. One set of five glass fragments were tested in the same location five times, the results of that test are shown in Table 4, and Figures 13 and 14. Table 4 shows the descriptive statistics from testing each glass sample five times in the same location, and the variation and standard deviation of those counts. Figure 13 and 14 are box and whisker plots that graph the variation and range in data calculated in Table 4 for lead and strontium, respectively. These figures show that the variation in raw counts for testing a sample in the same location varies between 10 and 70 counts for both strontium and lead.

A second set of glass samples were tested in five different locations on each sample for the follow up test. The results of the second test are shown in Table 5, and Figures 15 and 16. Table 5 has the descriptive statistics for each glass sample tested in five different locations. Figures 15 and 16 are box and whisker plots that show the variation in lead and strontium values from these tests. As shown in these figures, the raw counts vary between 80 and 130 counts for lead and between 300 and 600 counts for strontium. There is an obvious increase in the range of counts from the same location to this test, but due to the high range of counts for lead and strontium (lead 700-20,000; strontium 9,000-200,000) the variation in counts seen in these control tests is not significant enough to test all samples more than once in multiple locations.

**Descriptive Statistics**

| *Sample* | | *N* | *Minimum* | *Maximum* | *Mean* | *Standard Deviation* |
|---|---|---|---|---|---|---|
| **A** | **Strontium** | 5 | 20509.49 | 20574.89 | 20538.5680 | 32.7 |
| | **Lead** | 5 | 7120.15 | 7211.07 | 7163.0500 | 45.46 |
| **B** | **Strontium** | 5 | 20702.90 | 20809.96 | 20756.4780 | 53.53 |
| | **Lead** | 5 | 2205.38 | 2362.34 | 2275.5680 | 78.48 |
| **C** | **Strontium** | 5 | 20121.97 | 20153.21 | 20131.1880 | 15.62 |
| | **Lead** | 5 | 2186.44 | 2265.10 | 2234.2500 | 39.33 |
| **D** | **Strontium** | 5 | 20783.07 | 20877.24 | 20837.2820 | 47.085 |
| | **Lead** | 5 | 2261.15 | 2312.19 | 2295.4080 | 25.52 |
| **E** | **Strontium** | 5 | 21434.14 | 21483.77 | 21461.4900 | 24.815 |
| | **Lead** | 5 | 5843.97 | 5991.45 | 5904.1540 | 73.74 |

*Table 4. The descriptive statistics for the control test for testing glass samples in the same location multiple times.*

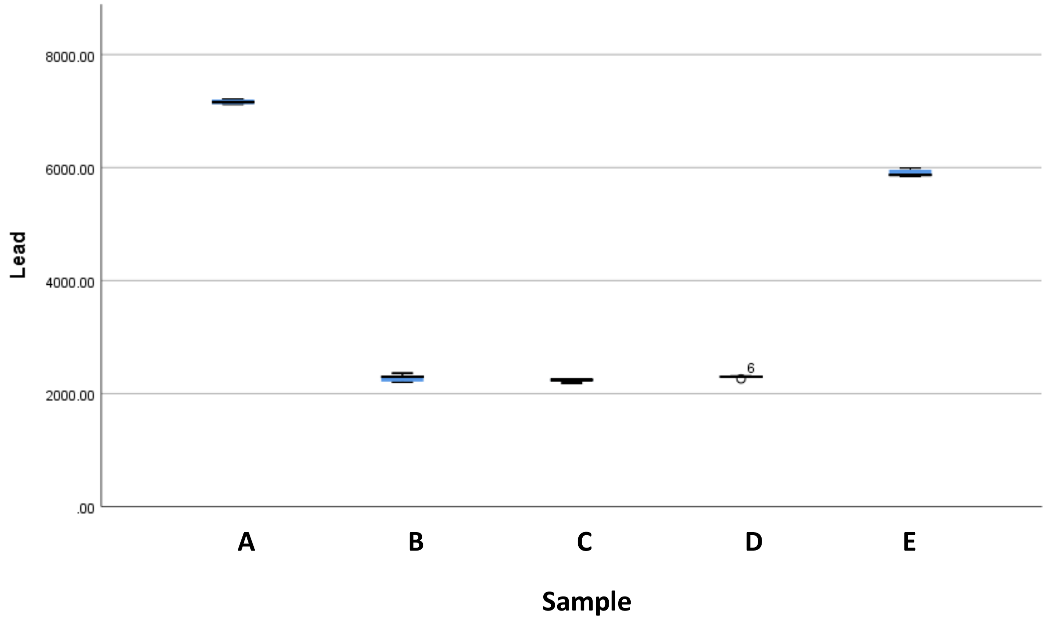

*Figure 13. A Box and Whisker plot mapping the variation in counts of lead for each glass sample tested in the same spot 5 times.*

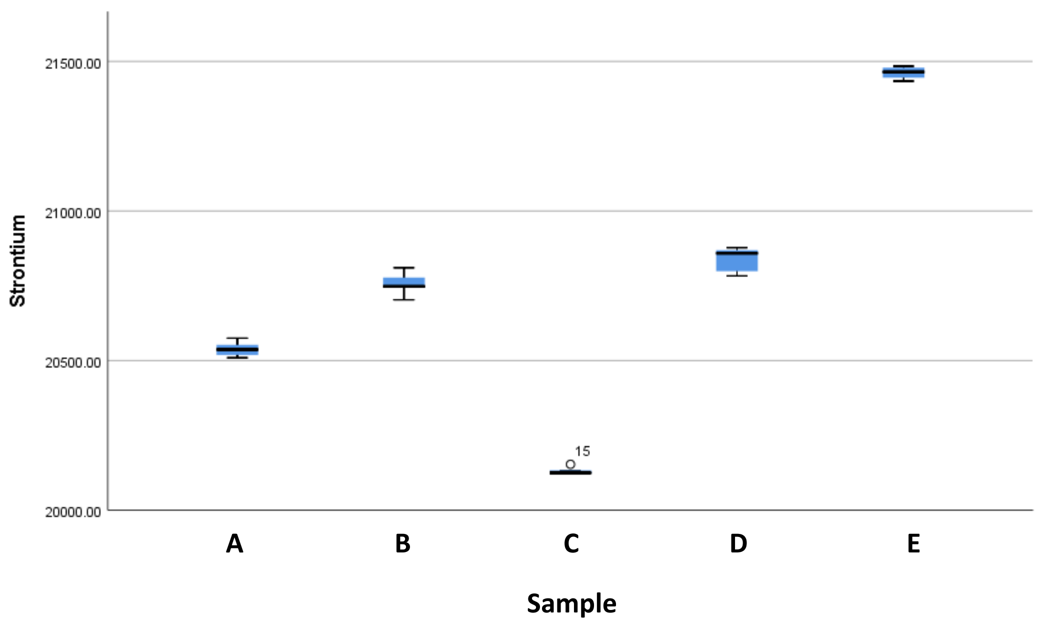


*Figure 14. A Box and Whisker plot mapping the variation in counts of strontium for each glass sample tested in the same spot 5 times.*

**Descriptive Statistics**

| *Sample* | | *N* | *Minimum* | *Maximum* | *Mean* | *Standard Deviation* |
|---|---|---|---|---|---|---|
| **A** | **Lead** | 5 | 1784.44 | 1988.56 | 1878.6800 | 102.06 |
| | **Strontium** | 5 | 22612.22 | 23627.90 | 23042.8700 | 507.84 |
| **B** | **Lead** | 5 | 3054.60 | 3296.21 | 3153.4900 | 120.805 |
| | **Strontium** | 5 | 44735.89 | 45534.77 | 45142.2300 | 399.44 |
| **C** | **Lead** | 5 | 1721.23 | 1980.32 | 1822.1340 | 129.545 |
| | **Strontium** | 5 | 42148.87 | 43576.28 | 43018.7880 | 713.705 |
| **D** | **Lead** | 5 | 2002.23 | 2248.92 | 2146.9820 | 123.345 |
| | **Strontium** | 5 | 22563.88 | 23783.93 | 23171.7800 | 610.025 |
| **E** | **Lead** | 5 | 5592.14 | 5929.96 | 5752.9760 | 168.91 |
| | **Strontium** | 5 | 28468.77 | 29546.94 | 29078.1080 | 539.085 |

*Table 5. Descriptive Statistics for the control test that tested glass samples in multiple locations 5 times.*

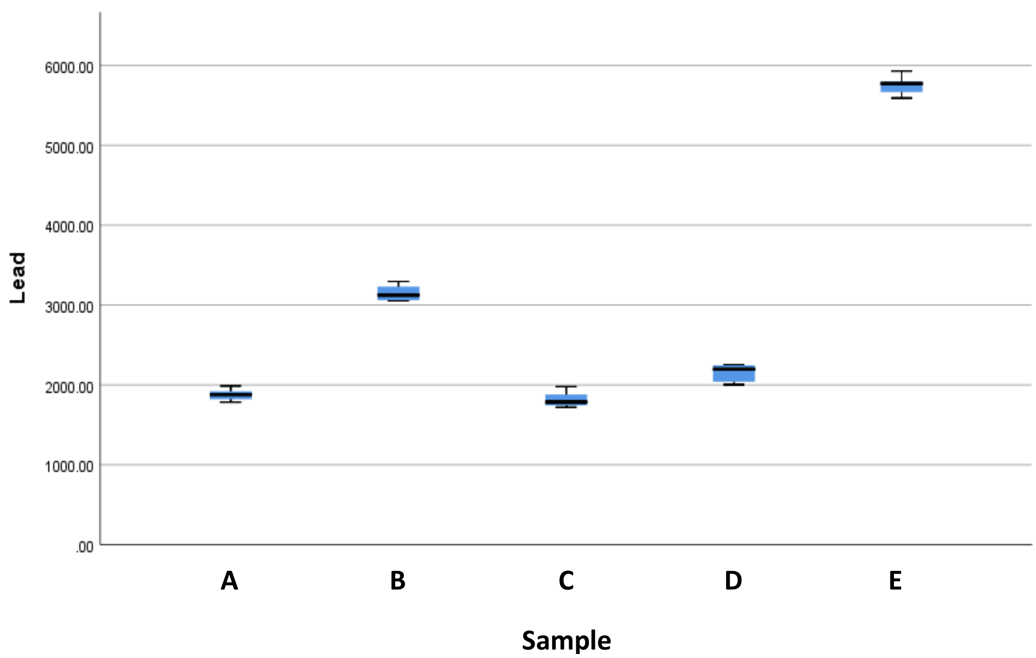


*Figure 15. A Box and Whisker plot mapping the variation in counts of lead for each glass sample tested in different spots 5 times.*

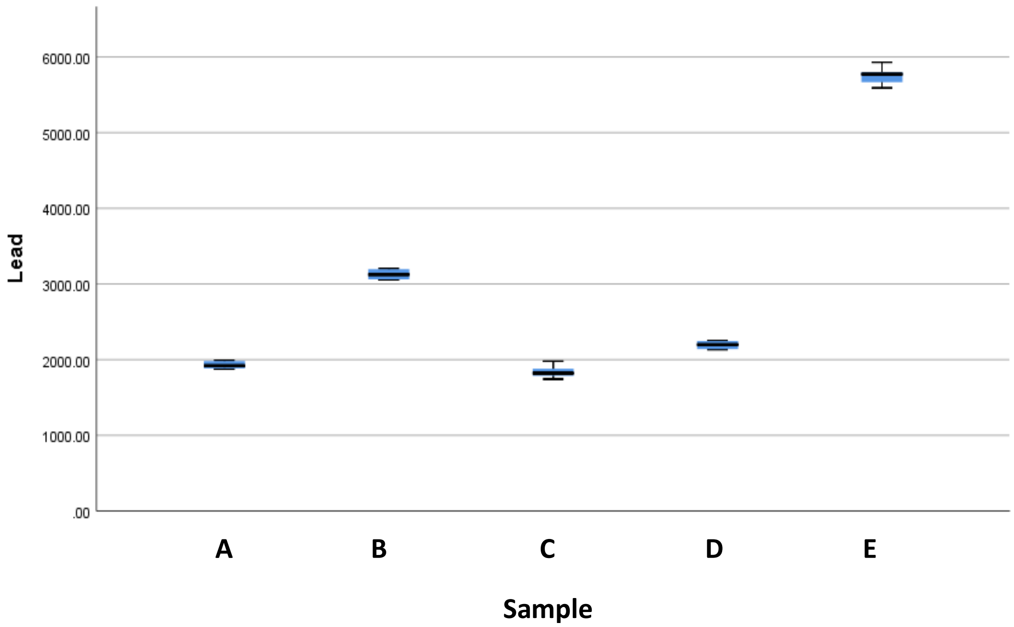


*Figure 16. A Box and Whisker plot mapping the variation in counts of strontium for each glass sample tested in different spots 5 times.*

**Limitations**

Limitations of the study conducted in this thesis include the use of the NPA method for creating relative abundances for characteristic identifications, and the size of the collections being tested. The NPA method is not a fully quantitative method, but rather a semi-quantitative process. Exact elemental compositions could not be established because of this. The use of a unit calibration would be helpful in establishing more substantial characterization of glass classifications and would aid in more substantial differentiation of production locations than this thesis can conclude. While these are possible places for further research, this study still enables productive classification of glass artifact classes and dating using the NPA for identifying clusters of indicative elemental counts.

The size of the collections is also a limitation because the Burial Hill and Standish site produced significantly fewer glass fragments. If these sites had produced as much glass as the Alden site, further clarifications and comparisons could be interpreted between the three sites as well as more conclusive production age, location, and evolution of glass production could be established. This is another place for further research, either to include more material from further excavations at Burial Hill or to apply this method to other archaeological sites within Plymouth colony.

**Strontium and Lead Classification for Identification and Dating**

As stated in the previous chapter, relative high strontium content is associated with glass produced using a kelp flux made between 1660-1835, which contrasts with relative low strontium content that is associated with window glass made between 1567 and 1700 (Dungworth 2012a; Dungworth 2013). Low strontium content is associated with production between 1567 and 1700, as 1567 is the year that continental glass makers first produced a new type of window glass in England that has a uniquely low strontium elemental signature, compared to glass produced before and after this date range. On the other hand, the variation in lead content between artifact classes is a new discovery and the process of associated relative high and low lead content needs further presentation here. By separating the mean lead content range of visually identified glass samples of case bottle and window glass fragments into two groups, compositional characteristics can be used to identify highly fragmented flat glass artifacts. The calculation and statistical validation for the lead characteristics are explained in the following chapter.

Visually identified case bottle and window glass fragments referred to in this thesis are glass fragments with defining characteristics that warranted a classification, based on physical criteria alone. The characteristic identifier for window glass is lead came staining around a straight edge of the glass fragment, shown in Figure 17. The identifying characteristic for case bottles is a curved edge paired with straight sides, seen in Figure 18.

*Figure 17. A window glass fragment with lead came staining.*

*Figure 18. A case bottle fragment with straight sides and a squared edge.*

**Testing Process**

The following section presents the actual process of testing each glass sample for this method. All samples were washed thoroughly with distilled water to ensure that any dust or oil from physical handling of samples would not skew the data. All samples were visually analyzed first to determine level of corrosion, thickness, and to check for superficial adherents. This process was to classify if the glass sample were sufficient for testing. If the glass fragment was too small to cover the detector on the spectrometer (>0.5-inch$^2$), that sample was noted and not tested.

A catalog was built in Microsoft Excel using the following attributes: level of flatness, thickness, color, corrosion level, surface roughness, presence of came staining, and ability to be tested. These attributes aided in determining if the artifact was window glass or case bottle glass. Glass samples were not tested if they were colorless or aqua in color or if the glass could be identified to be from a curved bottle. This is because typical window glass from domestic structures during the 17th century were green in hue or color. Colorless or aqua glass melts were usually made into tablewares during the 17th century and not typically used in domestic structure windows during this time (Dungworth 2011:24-26).

The three sites discussed in the previous chapter (Burial Hill, Alden, and Standish sites) produced green flat and case bottle glass fragment totals of 218, 1,533, and 21, respectively. Flat glass samples were removed from the testing pool mostly due to corrosion levels of the samples, and a few fragments were too small for the testing window of the pXRF. The total glass that was able to be tested from Burial Hill, Alden, and Standish are 164, 764 and 21, respectively (See Table 2).

Once the sample was washed and documented, the fragment was tested for 60 seconds using a portable Bruker Tracer III-SD spectrometer with a yellow filter and no vacuum. The raw spectra data was processed using the S1PXRF software package. Each sample was analyzed using the NPA of the raw data produced to calculate the number of channel counts or counts of each trace element present in the fragment. The results of the pXRF tests were documented in Excel and then the data was tested statistically with SPSS by using an Independent Sample test to determine if the data was statistically significant. The exact numbers presented in this thesis will likely not be able to be repeated perfectly in the future, but the relative abundances of high and low lead and strontium content can still be interpreted using this method.

Based on the testing method explained in this chapter and the historical background explained in chapter 2, the following chapter 4 delves into the results of the testing conducted for this thesis.

CHAPTER 4

RESULTS AND INTERPRETATION

## Initial Findings

This chapter presents the results from the pXRF testing conducted for this thesis. The three sites included in this study are the Alden site, the Standish site, and the Burial Hill site. Table 6 shows the total number of fragments considered for testing, the total fragments tested in this thesis and the number of visually identified window and case bottle fragments from the three sites. The process of this identification was discussed in the previous chapter. The Standish site has a significantly smaller sample size compared to the other two sites. This site was included in this project because the data produced from this thesis can be used to add important interpretations of the artifacts that remain from the Standish site.

| | *Alden* | *Burial Hill* | *Standish* | *Total* |
|---|---|---|---|---|
| **Total Fragments Considered for Testing** | 1,533 | 218 | 21 | 1759 |
| **Total Fragments Tested** | 764 | 164 | 21 | 949 |
| **Visually Identified Window Glass Fragments** | 72 | 0 | 1 | 73 |
| **Visually Identified Case Bottle Fragments** | 115 | 29 | 1 | 145 |

*Table 6. Table depicting the total amounts of tested and visually identified glass samples from the three sites.*

The strontium content for all the glass tested is broken down in Figure 19 which shows the distribution of the strontium counts by site. Figure 20 is a histogram that shows the strontium content frequency between the three sites. The lead content distribution separated by site is shown in Figure 21, and the lead content frequency is shown in a histogram in Figure 22. Both scatter plots and histograms were used to display this data to compare the distribution *and* frequency of counts for lead and strontium between the sites. Due to the disparity between the number of samples tested between sites, utilizing both chart types for the strontium and lead counts is useful to understand the data.

As seen in Figure 19, Burial Hill has a much larger range of strontium content as compared to the Alden or Standish sites. Figure 20 shows more clearly a high frequency of strontium counts around 22,000. The outliers below 17,000 counts were all reanalyzed. This reanalysis determined that these five outliers were slightly corroded, which possibly caused the skew in the data. This corrosion did not initially exclude these fragments from testing because it was not significant enough to cause the fragment to flake apart (delamination) but did cause slight iridescence.

Figures 21 and 22 show a bimodal distribution just under 5000 counts of lead, especially at the Alden site. This distribution can be seen at the Standish and Burial Hill site, but it is not as pronounced. Initially these distributions could be difficult to understand, but with the addition of the visually identified glass fragments, a possible explanation for these distributions becomes clear.

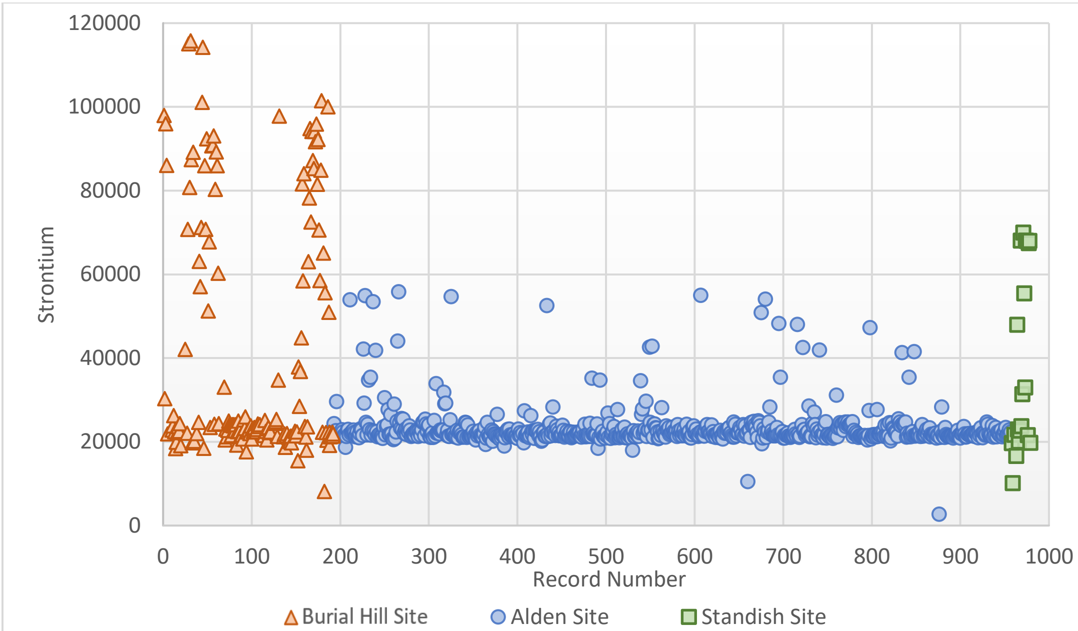


*Figure 19. A chart showing the distribution of the strontium counts for all 949 glass fragments tested from the three sites and included in the analysis of this thesis.*

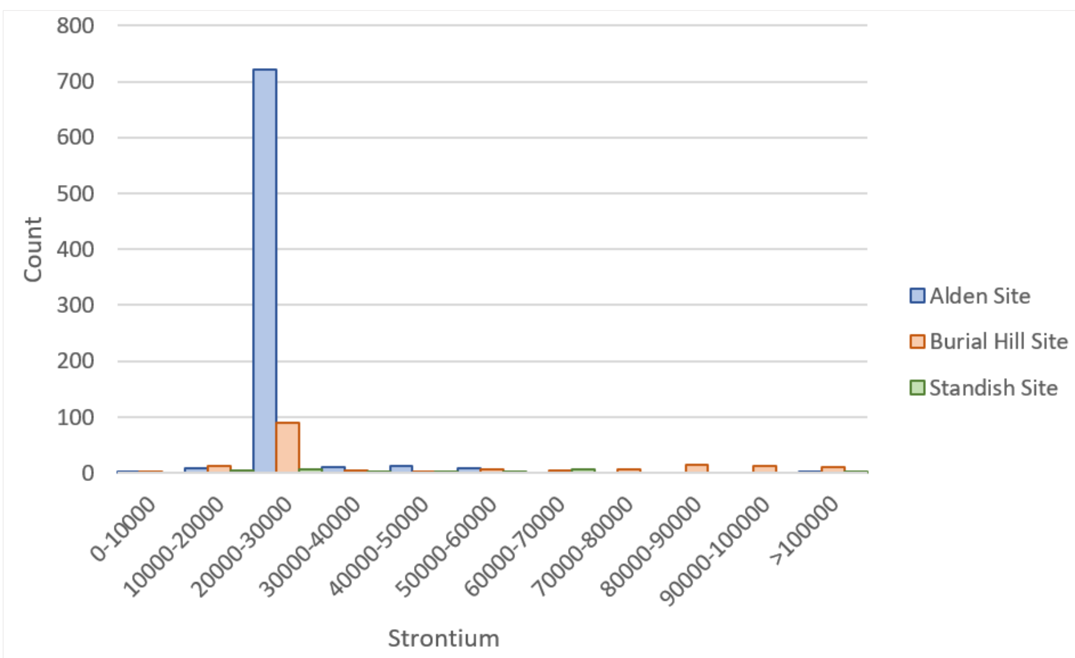


*Figure 20. Histogram showing the frequency of strontium counts at each of the sites.*

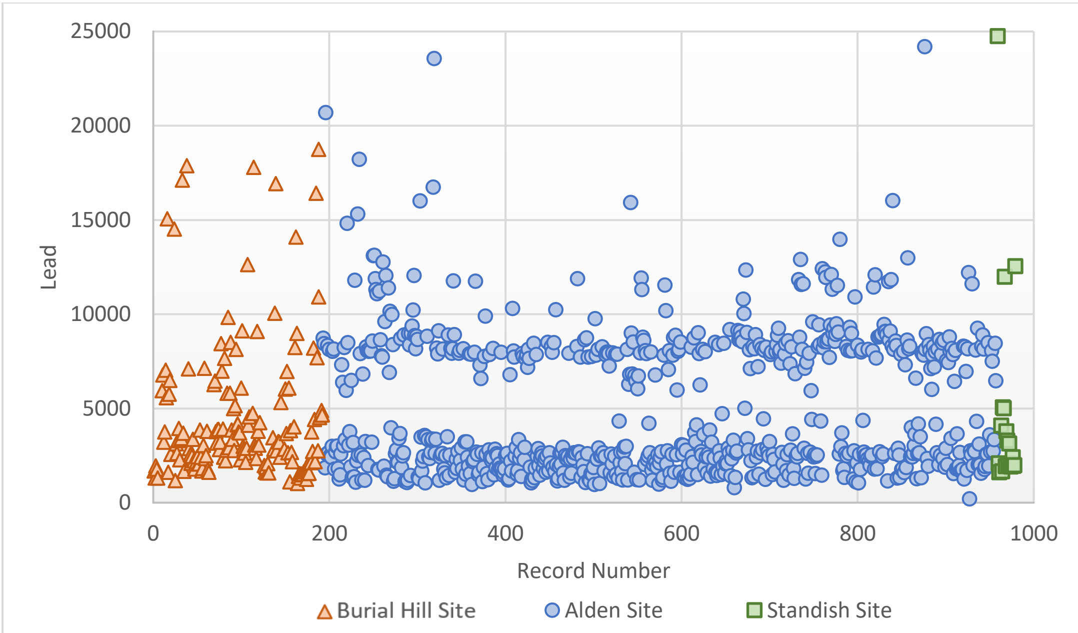


*Figure 21. A chart showing the distribution of the lead counts for all 949 glass fragments tested from the three sites and included in the analysis of this thesis.*

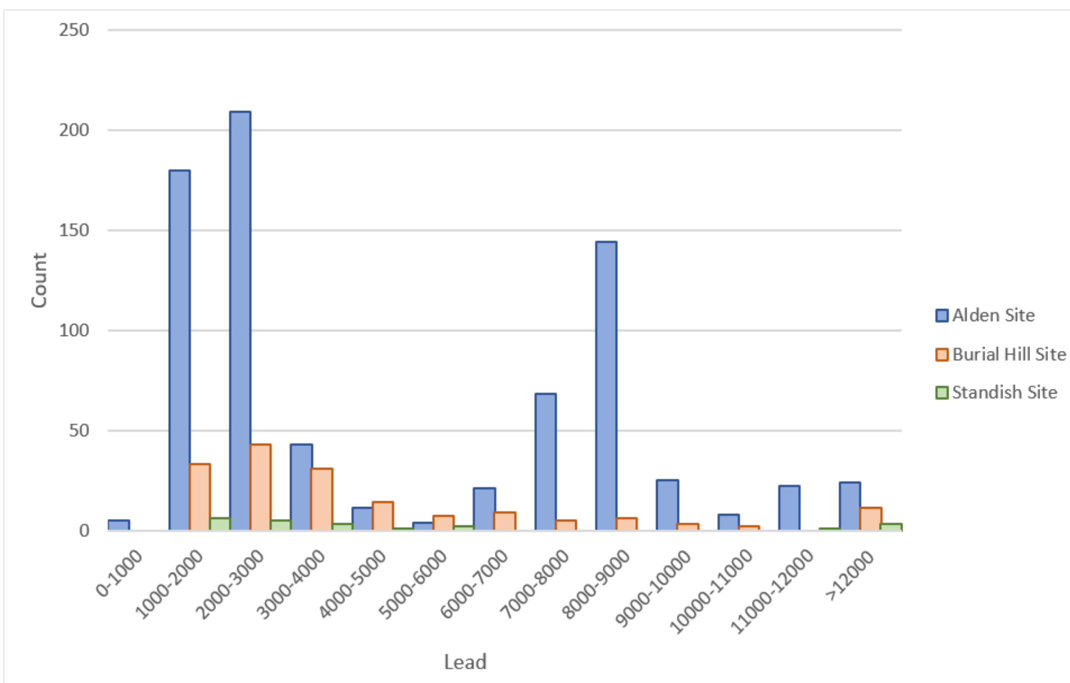


*Figure 22. Histogram showing the frequency of lead counts at each of the sites.*

Figures 23 and 24 are scatter plots the lead and strontium counts of all 949 flat glass samples tested displayed using two different variables. Figure 23 is separated by site, while Figure 24 is separated by unidentifiable and visually identifiable glass fragments. These figures are displayed here to show the distribution of strontium and lead counts together for interpretation of all the data collected in this thesis.

Figure 23 shows a wide range of lead counts for low strontium glass, but a tighter range of lead counts for high strontium glass. This figure shows that there is no high lead – high strontium glass at the three sites. This data could suggest a few interpretations about the addition of lead versus kelp ash (i.e. high strontium glass) into glass melts. This interpretation will be further discussed in the following chapter of this thesis. Figure 24 shows an important distinction about visually identifiable case bottles with high strontium content which will be explained later in this chapter.

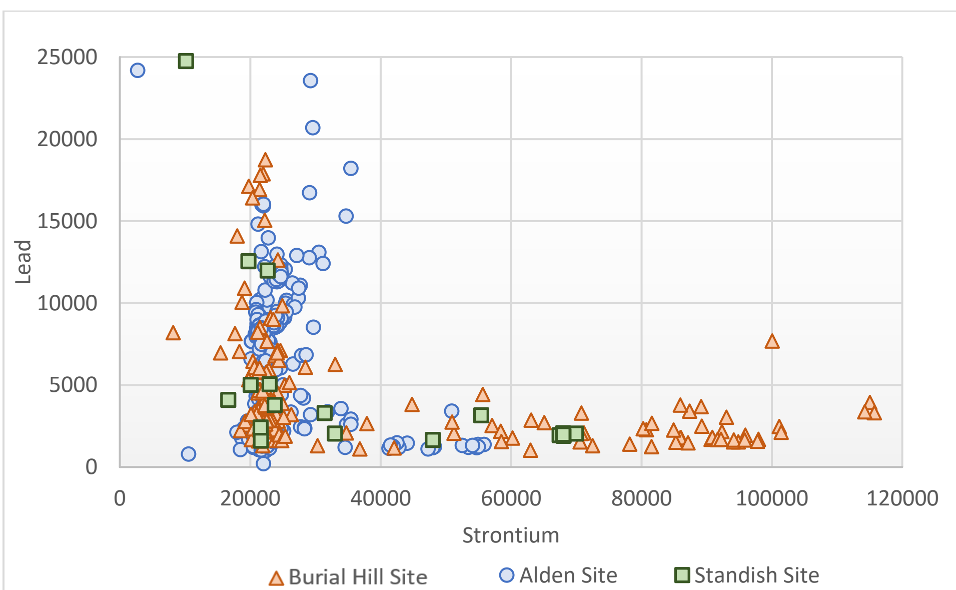


*Figure 23. Scatter plot showing the distribution of strontium and lead counts at the three sites.*

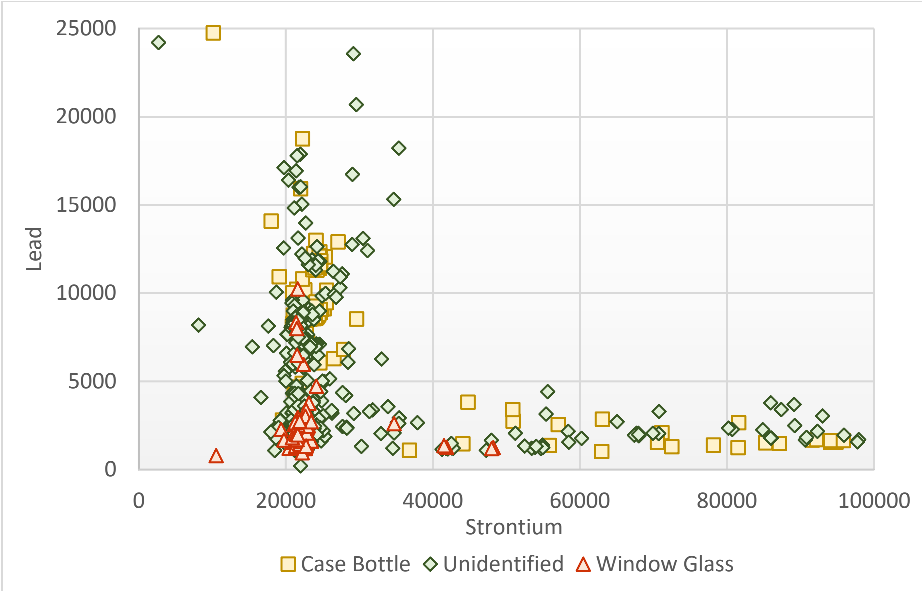


*Figure 24. Scatter plot showing the distribution of strontium and lead counts for visually identifiable case bottles and window glass fragments, and visually unidentifiable fragments.*

Shown in Figures 25 through 30 is a further breakdown of the strontium and lead values by site in histograms, including visually identified glass fragments coded in separate colors. These figures are all histograms to show the frequency distribution of the count data between sites. This helps to separate out the data so it can be compared more thoroughly across the sites and by artifact type.

The first three figures are histograms showing the frequency of strontium counts at the three sites. Figure 25 shows the strontium variation from the Alden site, which depicts a similar high frequency of counts around 22,000, also seen in Figure 19 and 20. This figure does not  show a trend in strontium content with the visually identified glass fragments, as all of these fragments are within the 20,000-30,000 count range. Although, based on the high frequency of counts within this range, an important conclusion can be drawn by comparing the strontium content range from the Alden site to the other two sites. All range comparisons are discussed after Figures 26 through 30 are presented.

Figure 26 shows the range of strontium counts produced from the glass fragments uncovered at Burial Hill. This data has a similar frequency of strontium counts around 22,000 seen in Figures 19, 20 and 25, but Figure 26 shows a wider range of counts between 30,000 to over 100,000. The spatial distribution of flat glass fragments to the east and west of the crypt at Burial Hill is expanded upon in the following section of this chapter.

The following figure, Figure 27 show the strontium frequency for the Standish site. The strontium counts shown in this figure represent two clusters. One of these clusters is around 22,000 counts, similar to the groupings in the low strontium range from the other sites. A second cluster can be seen around 70,000 counts which is unique, compared to the other two sites higher strontium ranges.


*Figure 25. Histogram showing the frequency of strontium counts for visually identifiable and unidentifiable glass fragments from the Alden site.*

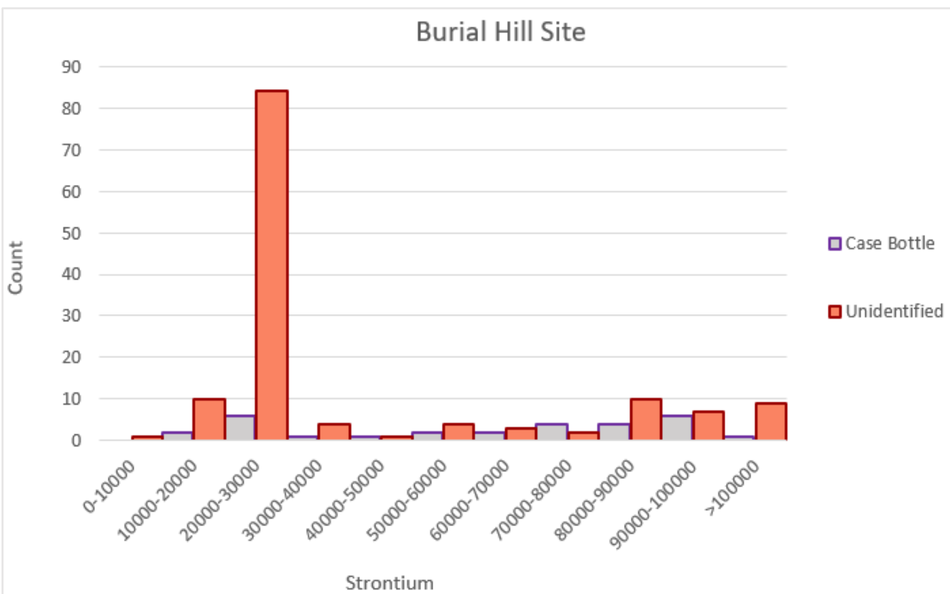


*Figure 26. Histogram showing the frequency of strontium counts for visually identifiable and unidentifiable glass fragments from the Burial Hill site.*

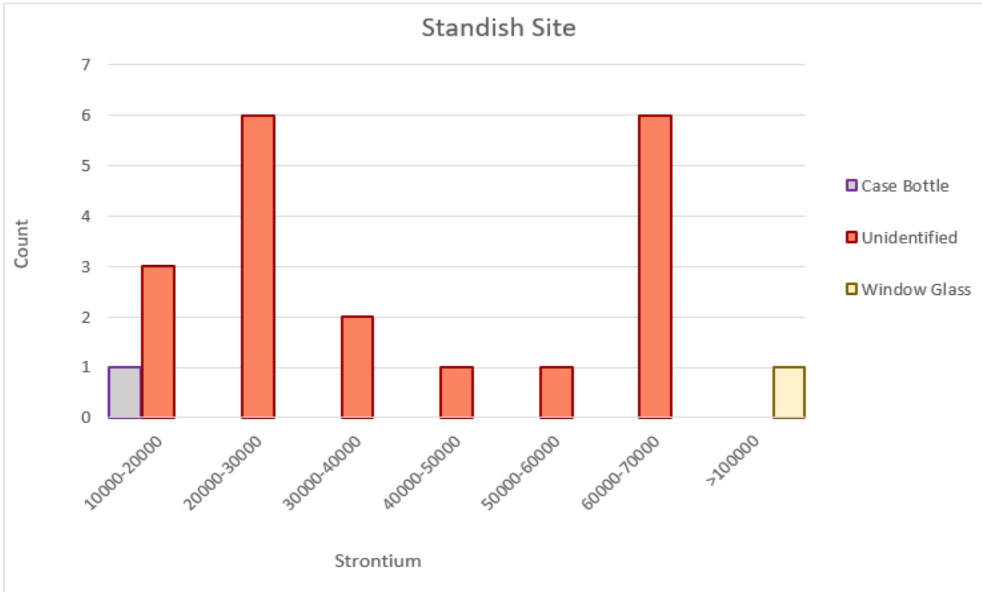


*Figure 27. Histogram showing the frequency of strontium counts for visually identifiable and unidentifiable glass fragments from the Standish site.*

The following figures (Figures 28 through 30) are histograms showing the frequency distributions of lead counts for visually identifiable and unidentifiable fragments between the three sites. Figure 28 shows the lead count variation for the Alden site with an important bimodal distribution of visually identified glass fragments. This distribution indicates that all visually identified case bottle fragments produced lead counts around 7,000 and above, and most visually identified window glass fragments had lead counts below 5,000. The classification for identifying case bottles and window glass based on their lead content is statistically tested later in this chapter.

Figure 29 shows a slightly bimodal distribution of lead values, but this distribution is not as substantial as at the Alden site, seen in Figure 28. This figure also shows that the lead distribution which seemed to be corelated with visually identified case bottles at the Alden site, is not represented at Burial Hill. In fact, there are multiple groupings of visually identified case bottles with lead counts *below* 5,000. The samples in the group around 1,000 lead counts produced strontium counts between 30,000 and 100,000. The group with lead counts around 4,000 are glass fragments that are correlated with strontium counts just above 20,000. This is an important pattern that is discussed later in this chapter (see Figure 33). A final important note about the glass fragments from Burial Hill, is that there are 0 visually identified window glass fragments excavated as of 2018 at this site.

The final figure in this group (Figure 30) shows the lead distribution at the Standish site. This figure depicts a similar cluster below 5,000 counts, as seen at the other sites. It is important to note that the Standish site only produced one visually identified case bottle and window glass fragment, and had a smaller sample size compared to the other two sites.

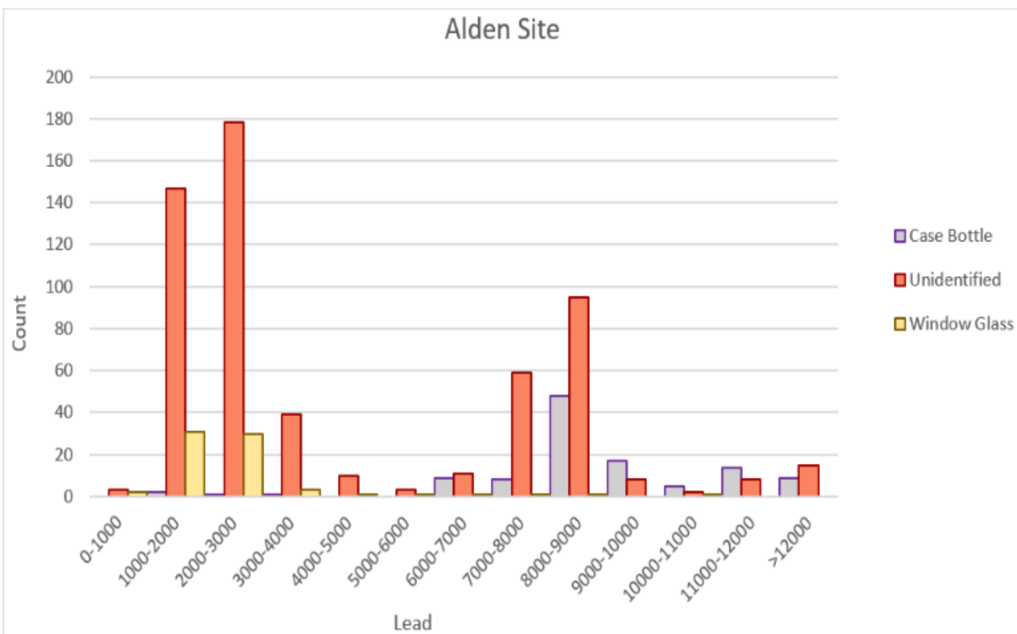


*Figure 28. Histogram showing the frequency of lead counts for visually identifiable and unidentifiable glass fragments from the Alden site.*

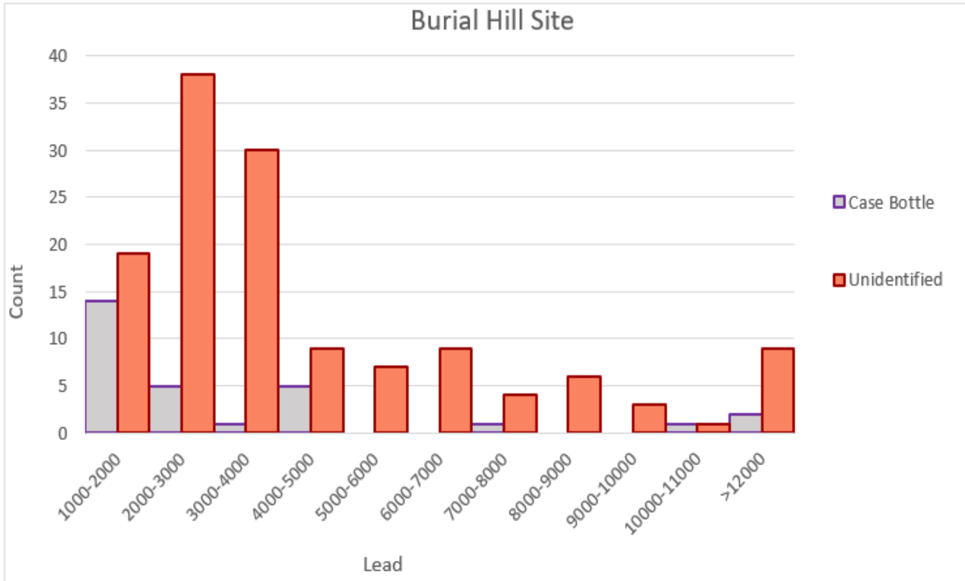


*Figure 29. Histogram showing the frequency of lead counts for visually identifiable and unidentifiable glass fragments from the Burial Hill site.*

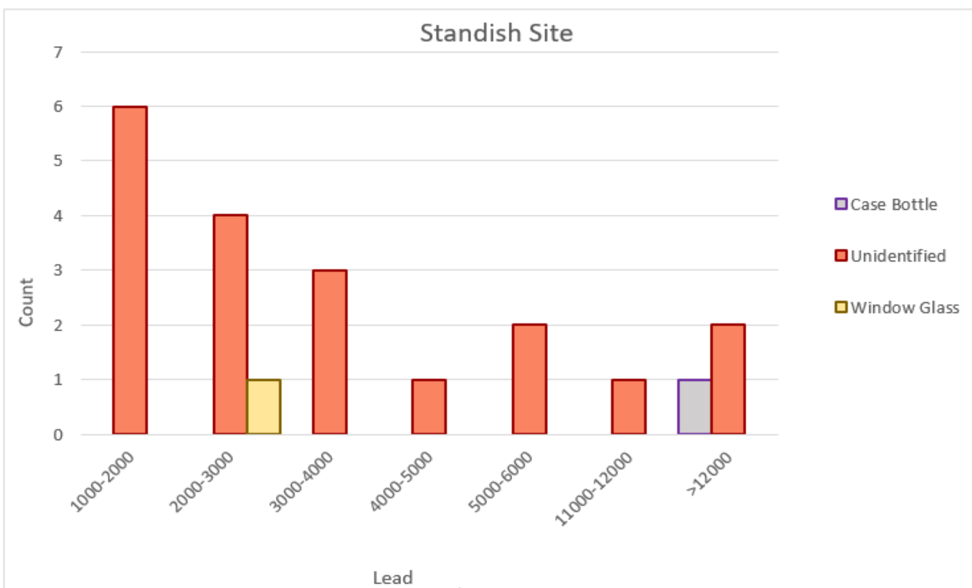


*Figure 30. Histogram showing the frequency of lead counts for visually identifiable and unidentifiable glass fragments from the Standish site.*

## Initial Strontium Interpretations

The interpretations discussed in this section are in reference to the data presented in Figures 25 through 30. The classification for identifying glass fragments, which is in regard to the lead content of the glass, is expanded upon later in this chapter. Figures 25, 26, and 27, depict the strontium content at the three sites, which fall into distinct groupings.

Based on the analysis conducted by Dungworth, it is assumed that the high strontium content glass tested in this study would have been produced after 1660, when kelp was added as a flux to window glass production. From this conclusion, the entire dataset was separated into two sets based on their strontium content. The first is high strontium content glass (with strontium content higher than 29,000), which likely dates to after 1660. The second is the low strontium content glass (with strontium content lower than 29,000) that likely dates to between 1567 and 1700. This number was chosen as it was more than 3,000 counts outside the range of highly concentrated low strontium counts at the three sites. This number therefore accounts for possible outliers in the low strontium group, as a majority of the low strontium glass has strontium content within 1000 counts of 22,000.

### *Low Strontium Glass*

All three sites have a clear strontium group at 22,000 counts. This group of low strontium content correlates with glass that would have been produced throughout the $17^{th}$ century without the use of kelp as a flux. These glass samples likely date within the $17^{th}$ century as the use of kelp (high strontium or mixed alkali glass) in window glass production completely overtakes HLLA (high lime-low alkali or low strontium) glass production at the end of the 17th century (Dungworth 2011:33-40; Dungworth 2013:119-222). It is important to note that case bottles were produced both in green glass vessel and window glass production houses (Godfrey 1975:150). This is important as it therefore includes case bottles in with glass produced with kelp ash, that have an indicatively high strontium content.

The high frequency of low strontium content indicate the use of all three sites throughout the 17th century and the popularity of HLLA (low strontium) glass throughout this period. This frequency could also indicate the time differential from when kelp ash glass began being produced to when it was installed in structures in the colonies. As low strontium glass was produced throughout the 17th century, in addition to the high expense and lack of need to refurbish window glass very often, the post-1660 high strontium glass was not be as frequent at these sites as the low strontium glass.

*High Strontium Glass*

All three sites have different ranges of high strontium content which could suggest multiple interpretations. The Alden and Standish sites have tighter high strontium count ranges (30,000-60,000; 40,000-80,000 respectively), as compared to the Burial Hill site (30,000-100,000), which can also be seen in Figure 19. Based on the ranges of high strontium counts compared across the three sites, the glass samples likely either range in date of production or production location or more likely, both.

The Alden site has a tighter range, which could be accounted for based on the tighter occupation age range as compared to the Burial Hill site. While the glass tested from Burial

Hill was only included if it was green in color and was produced from contexts with diagnostic 17th century artifacts, many of the areas that produced these glass fragments were mixed contexts. Therefore, there is a possibility that the wider range of high strontium content from the Burial Hill site is due to the glass tested being produced after 1700, with the high strontium glass from the Alden site being produced between 1660 and 1700. As the Alden site was most likely abandoned around 1700 and was likely not used as a dumping ground, the presence of a tighter range of high strontium content at this site could be logical, since Burial Hill was occupied by businesses and residences in the second half of the 18th century. Also, as noted by Dungworth (2013), glass houses that used kelp ash would produce glass with varying strontium content. This applied to separate glass houses as well as the same glass house producing glass over a long period of time (Dungworth 2013:121).

However, this wide range of strontium content glass was produced in both sealed and mixed 17th-century contexts at the Burial Hill site. As the sealed 17th-century contexts definitively date *within* the 17th century, this suggests it is more likely the larger range in strontium content at Burial Hill is due to the glass being produced at different locations during the 17th century, rather than later in the 18th. Since the Burial Hill site likely encompasses multiple properties owned by at least two different families, there is a possibility for variability in types of goods purchased. This would increase the opportunity for a variety of goods to be accessed at this location with a larger number of people to bring these goods to the site. In comparison, at the Alden site, where only the Alden family was supplying glass products to the site. The most likely interpretation of this data is that the glass was produced at varying locations based on the sealed 17th-century contexts at Burial Hill and the differing ranges of high strontium content between the two sites.

The Standish site, which burned down around 1665, has a cluster of high strontium glass that does not fit into the ranges at the other two sites. This glass was either very new glass brought to the colonies shortly before the structure burned down, or the glass was deposited in the cellar hole of the original structure while it was used as a dumping location (Heitert 2017:22-27). The cluster of high strontium counts around 70,000 counts at this site are possibly glass samples that were produced in the same glass house or around the same time. This is due to their strontium counts ranging in only 1000 counts and their lead counts ranging by less than 500 counts. This limited range in counts for strontium and lead content found in multiple glass samples is seen in low strontium samples at all three sites. However, the high strontium content glass at all three sites have much wider ranges between samples, as seen in the high strontium content ranges at the Alden and Burial Hill sites. The distinct difference in strontium count range between low strontium and high strontium is further discussed at the end of this chapter.

There is one visually identified window fragment from the Standish site which produced strontium counts that is significantly outside the typical strontium range (160,000 counts). This fragment definitively dates to after 1660 but possibly dates to later in the 17th century or 18th century or was produced in a different location than any other sample tested. The most likely interpretation is that this glass fragment was deposited at the site while the area was being used for dumping in the 18th century. This possibility seems the strongest as there is a common oral tradition that the Standish cellar hole was used as a trash pit once the structure burned down around 1665 (Heitert 2017:22-27).

The interpretations above are based on the similar low strontium content ranges and different high strontium content ranges for the three sites. Both the high and low strontium content can also be used to date the glass fragments, which can help interpret the date of deposits at these sites. For the Burial Hill site in particular, as the excavation style was precise, areas which have been identified as separate residences can possibly be dated using the strontium content presented here.

As discussed in chapter 2, the areas west and east of the burial crypt on Burial Hill have provisionally been interpreted as two separate occupations by separate families. Although not enough glass samples were produced from the area west of the crypt to establish statistically significant patterns, some general impressions can be suggested from the glass fragments spatial distribution on Burial Hill. Figure 31 plots the glass fragments based on their location and depositional context on the Burial Hill site. Within both sealed 17th-century and mixed contexts there is an even spread of high and low strontium glass that were uncovered on both sides of the crypt. Based on this distribution of glass in sealed 17th-century contexts, this data would suggest that these areas were occupied during similar time frames, throughout the 17th century.

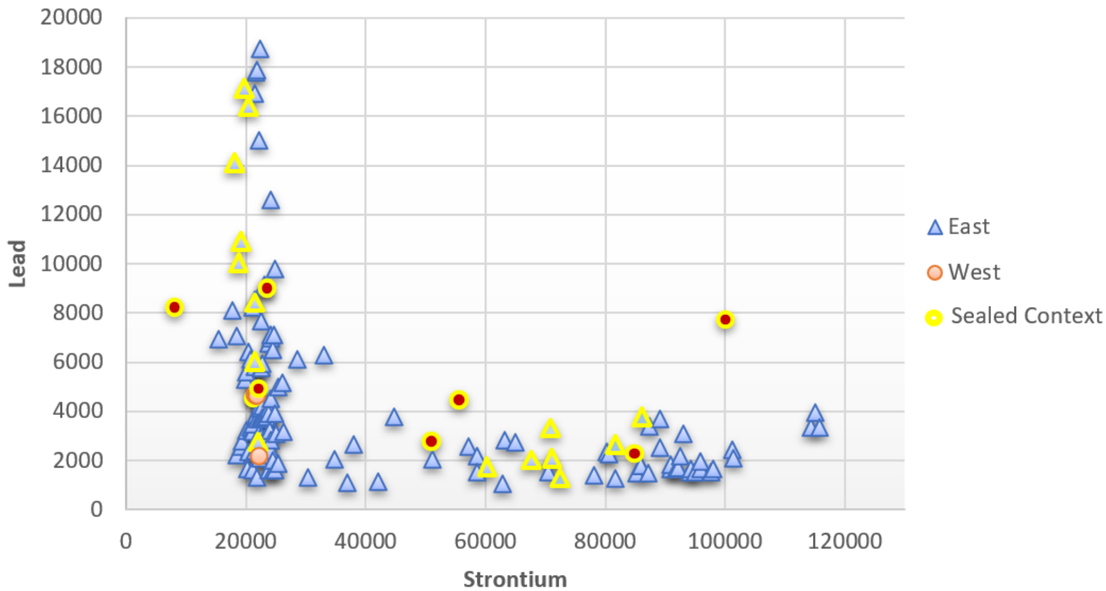


*Figure 31. Scatter plot displaying the spatial distribution of glass fragments excavated east and west of the crypt on Burial Hill.*

**Initial Lead Interpretations**

In the previous section, Figures 28, 29, and 30 depict the lead content distributions from the three sites. These figures revealed the possibility of using lead content to differentiate window and case bottle glass fragments that lack identifying features. In particular, the distinct bimodal distribution of lead content from glass uncovered at the Alden site, seen in Figure 28, showcases the ability to use lead content as an identifier. All of the visually identified case bottles have lead content around 7,000 counts, while most of the visually identified window glass fragments have lead counts around 3,000. Even though this distribution of lead values is not reflected as significantly at the other two sites, Figures 29 and 30 still suggest that lead content can be used to identify case bottles versus window glass fragments. The following section statistically tests the validity of this conclusion by determining if the lead values produced from visually identified fragments are random or if there is a pattern within the data. Statistical testing is required for this conclusion as using lead to differentiate case bottle and window glass is a new discovery by this study, unlike the connection between kelp ash and strontium content, which was previously established.

*Identification based on Lead Content*

The first step in testing this pattern was to define the center of the world distribution of the lead counts for all visually identified case bottles and window glass fragments from the three sites. This was done so lead content identifying characteristics could be built and then applied back on the same glass fragments to determine the error of those built characteristics.

To determine the world distribution of lead counts between the two artifact classes, the visually identified case bottles and window glass fragments were separated into two sets. Table 7 details the steps followed for determining the center of the lead content between the two artifact types. In the left column are the mean and standard deviation of the lead counts for visually identifiable case bottles. The right column has the mean and standard deviation of the lead counts for visually identifiable window glass fragments. A standard deviation is a measure of the variation of a dataset relative to the mean of that dataset. Therefore, if the standard deviation of the lead content for visually identified case bottle is *subtracted* from that datasets mean, and the standard deviation of the lead content for visually identified window glass is *added* to that datasets mean, the median value between those two equations would be the center value between the two datasets. The resulting median value from these calculations is 4,293 counts.

| **Median Calculations** | |
|---|---|
| *Mean lead for Case Bottles* | *Mean lead for Window Glass* |
| **8,067** | **2,484** |
| *Standard Deviation for Case Bottles* | *Standard Deviation for Window Glass* |
| **3,618** | **1,654** |
| *1 Standard Deviation Lower than the Mean for Case Bottles* | *1 Standard Deviation Higher than the Mean for Window Glass* |
| **4,449** | **4,138** |
| *Median Between the Standard Deviations:* | ***4,293*** |

*Table 7. The calculations for determining the median of the lead values for visually identified case bottles and window glass.*

Once this number was determined, additional attributes were taken from the visually identified fragments to build the best characteristics for a quantifiable classification of the artifact types. Figure 32 shows the lead content of the visually identified glass fragments plotted against those fragment's thicknesses. This figure shows a further designation between case bottles and window glass based on their thickness. Case bottles tend to have higher lead values and have varying thicknesses, while window glass tends to be thinner with lower lead values.

There are 20 outliers shown in this graph. Six of those outliers are window fragments. After examination of those specific artifacts, it was determined that all six of those samples were heavily pitted from corrosion which possibly left lead residue from the cames inside the pitting, causing a higher lead content. The remaining 14 outlier samples are case bottle fragments. Of those fragments, nine have strontium content consistent with a later production date, which is discussed later. The final five outliers were all excavated from sealed 17$^{th}$-

century contexts at Burial Hill. These final outliers are interpreted in the final section of this chapter.

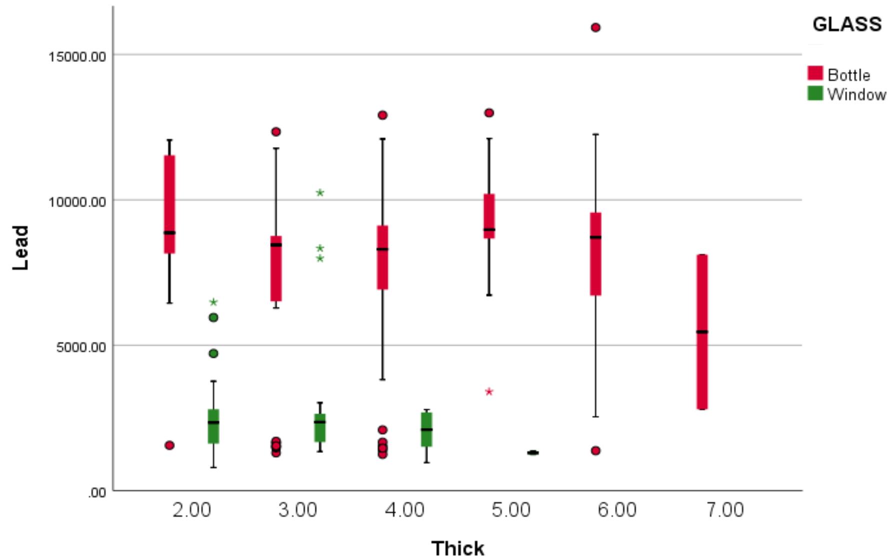


*Figure 32. Lead counts compared to the thickness in mm for visually identified artifacts types.*

In this figure the visually identified window glass fragments that are 4mm thick can be misleading. The number of case bottles that are 4 mm thick compared to window glass fragments that are also 4 mm thick, is a ratio of 3 to 1, suggesting it is more likely a flat glass fragment that is 4 mm thick would be a case bottle. Even with the outliers and stipulations presented, a majority of the visually identified case bottles can be identified by using the following characteristics. Fragments with counts above 4,293 can be identified as case bottles and fragments with counts lower than 4,293 that are 3mm thick or thinner can be identified as window glass fragments. The validity of these characteristics to classify flat glass was tested by using the Independent Sample *t* Tests to identify statistical significance in the separated datasets.

*Statistical Significance*

Table 8 shows the breakdown of the Independent Samples *t* Test. This test compares two associated groups of data based on their separate mean values to determine if the average of those groups is statistically distinct from each other. In this case, the visually identified case bottle and window glass fragments were the independent variables or groups being compared (categorical values). These independent groups were compared based on the mean values (continuous value) of their lead and strontium content, and thickness in separate Independent Samples Tests. This test was used to determine if the characteristics of the two independent groups were statistically different from one another. This significance would suggest that the distributions in the data presented above is not arbitrary (Kent State Library 2020).

The following discussion presents the tests automatically computed during an Independent Samples *t* Test that are all shown in Table 8, which is an output from SPSS. The first half of Table 8, labeled Group Statistics, shows the initial mean, standard deviation, and the standard error of the mean (labeled std. error mean) of the three separate Independent Samples Tests. A standard error mean is the *typical* range between the continuous values (lead and strontium content and thickness) and the mean. The standard error is determined by measuring how far the mean of a sample of that dataset varies from the mean of the whole dataset. This value is different from the standard deviation, which is measuring the variation in a whole dataset from that data's mean (Kent State Library 2020). These calculations are used in the Independent Sample Test to determine if the independent groups (case bottles and window glass) are statistically different based on their continuous values (lead, strontium, and thickness).

The second half of Table 8, headed with Independent Sample Test, shows the result of this test. The first two columns with numerical data have the heading “Levene’s Test for Quality of Variances.” This first test is to determine if the continuous values (lead, strontium, and thickness) are equally variable for the two independent groups. This means that the Levene’s Test is calculating if the data is equally spread out around the mean of each independent group (case bottle and window glass). The columns under the Levene’s Test heading, “F” and “Sig.”, are values used in deciding which row titled “equal variances assumed” or “equal variances not assumed” is read to determine the significance of the independent groups (Kent State Library 2020).

The “F” in the first column represents the value used in calculating the statistical significance of the variation from the mean of the continuous values (lead, strontium, and thickness). The second column “Sig.”, which stands for significance, is the p-value of the independent groups. The p-value is the statistical probability that the null hypothesis is true. In this test, the null hypothesis would be that the two independent groups have ranges of continuous values that are random, or that there is no significance to the differences in the datasets. Therefore, if the “Sig” value is very low, then there is very *little* probability that the variance of the lead, strontium and thickness values between the case bottle and window glass datasets is random, and vis versa (Kent State Library 2020).

If the “Sig.” is less than .05 than the “equal variances are not assumed” row is read from for the remainder of the table, as there is *not* an assumption that the variation between the two independent group's (case bottles and window glass) continuous values (lead, strontium and thickness) is equal, and vice versa. The "Sig." values simply determines which row (equal variances assumed or not assumed) is read from for the remainder of the table for each continuous value (lead, strontium, and thickness) (Kent State Library 2020).

**Group Statistics**

| | *Glass Type* | *N* | *Mean* | *Std. Deviation* | *Std. Error Mean* |
|---|---|---|---|---|---|
| **Lead** | **Case Bottle** | 145 | 8067.73 | 3618.628 | 300.511 |
| | **Window** | 73 | 2484.84 | 1654.730 | 193.672 |
| **Strontium** | **Case Bottle** | 145 | 31524.87 | 20253.381 | 1681.952 |
| | **Window** | 73 | 27408.96 | 25225.863 | 2952.464 |
| **Thickness** | **Case Bottle** | 145 | 3.83 | 1.354 | .112 |
| | **Window** | 73 | 2.88 | .816 | .095 |

**Independent Samples Test**

| | | *Levene's Test for Equality of Variances* | | *t-test for Equality of Means* | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *F* | ***Sig.*** | *t* | *df* | ***Sig. (2-tailed)*** | *Mean Difference* | *Std. Error Difference* |
| Lead | Equal variances assumed | 22.311 | **.000** | 12.528 | 216 | .000 | 5582.898 | 445.630 |
| | **Equal variances not assumed** | | | 15.616 | 214.466 | **.000** | 5582.898 | 357.513 |
| Strontium | **Equal variances assumed** | 2.119 | **.147** | 1.302 | 216 | **.194** | 4115.914 | 3162.377 |
| | Equal variances not assumed | | | 1.211 | 119.997 | .228 | 4115.914 | 3397.941 |
| Thickness | Equal variances assumed | 25.711 | **.000** | 5.554 | 216 | .000 | .958 | .172 |
| | **Equal variances not assumed** | | | 6.493 | 209.127 | **.000** | .958 | .148 |

*Table 8. Independent Sample t Test used to determine if the mean continuous values (lead, strontium, and thickness) for the independent variables (case bottles and window glass) are statistically different.*

For the lead test between case bottles and window glass, the “Sig.” was .000 meaning that the row titled “equal variances not assumed” was used. Following this row for the lead test, under the Sig. (2-tailed) column, the value is .000 for the lead values compared between case bottles and window glass (the row to read is bolded). This means there is a statistically significant difference between the lead values of the case bottles and window glass datasets. The Sig. (2-tailed) column is the significance, or probability the data is not random, calculated through the “*t”* statistic with the “*df”*, or degrees of freedom. Much like the “F” statistic from the Levene’s Test, the “*t”* statistic is a statistical value calculated through the test to determine the probability that the case bottle and window glass datasets are not randomly different and therefore has significance. Degrees of freedom are the number of independent values that can be assigned to a statistical distribution, which is simply the number of glass samples tested, minus one. The final two columns in Table 8 are headed with t-test for Equality of Means, which is the estimation of the difference between the means of the two independent groups (case bottles and window glass). These last two columns are as complimentary to the rest of the Independent Sample *t* Test and is not be discussed further (Kent State Library 2020).

The next test is for the strontium count ranges between the case bottle and window glass values. In this test the “Sig.” column has a .147 value which means the “Equal variances assumed” row would be followed (row in bold). The Sig. (2-tailed) for the strontium test was .194, which means that the strontium value ranges of the visually identified case bottles and window glass fragments were not meaningfully distinct from one another. The final test shown in Figure 8 is for thickness, which produced a “Sig.” of .000, meaning the “equal variances not assumed” row was used. In the Sig (2-tailed) column for the thickness test, the produced significance was .000. This means that the compared thickness values between the case bottles and window glass fragments is statistically significant.

### *Interpreting Significance*

Based on Table 8, the difference in lead counts and thickness values between visually identified case bottles and window glass fragments is statistically significant and not random. This suggests that the lead values and the thickness of fragments are useful characteristics in separating the two types of glass fragments. The strontium values are not significant. This is due to the high frequency of samples with strontium values around 22,000 counts. While the strontium values are not statistically significant, this does not mean there is not information that can be learned from the strontium content in the glass. From the tests proving statistical significance seen in Table 8, the distinctions for lead values and thickness of fragments was further tested to determine their accuracy in identifying case bottle glass versus window glass.

### *Accuracy Testing of Classification Values*

The following test used visually identified glass fragments to test identifying characteristics listed in the previous section, against the actual characteristics of these identified fragments. This was done to determine the percentage of accuracy for those characteristics when they are applied to already visually identified fragments. As seen in Figure 32, window glass samples typically range from 1 to 3 mm with lead counts less than 4,293, while case bottle glass range from 1 to 7 mm with a typical lead count above 4,293. Therefore, the thickness classification was only used for identifying window glass.

The visually identified samples were "classified" as case bottles if they had a lead content higher than 4,293, and as window glass fragments if the fragment had a lead content lower than 4,293 and were between 1 and 3 mm thick. The results of this test are shown in Table 9. Using these parameters, of the 145 visually identified case bottles, 6 were incorrectly "classified." For the 73 visually identified window glass fragments, 25 were "classified" incorrectly in this test. This is a 14% inaccuracy.

| | **Classification Characteristic** | | |
|---|---|---|---|
| | *lead > 4,293* | *Thickness < or = 3 and lead < 4,293* | *Total* |
| **Case Bottle** | 120 | 6 | 126 |
| **Window** | 25 | 67 | 92 |
| **Total** | 145 | 73 | 218 |

*Table 9. The visually identified glass fragments tested against the characteristics of lead and thickness.*

*Case Bottle Dating*

Once these tests were performed to determine the validity of classifying case bottle glass from window glass fragments within a 86% accuracy (14% inaccuracy), a further classification was added to the list of characteristics used to identify and date flat glass fragments. Figure 33 shows the visually identified case bottles from the three sites with their lead content plotted against their strontium content.

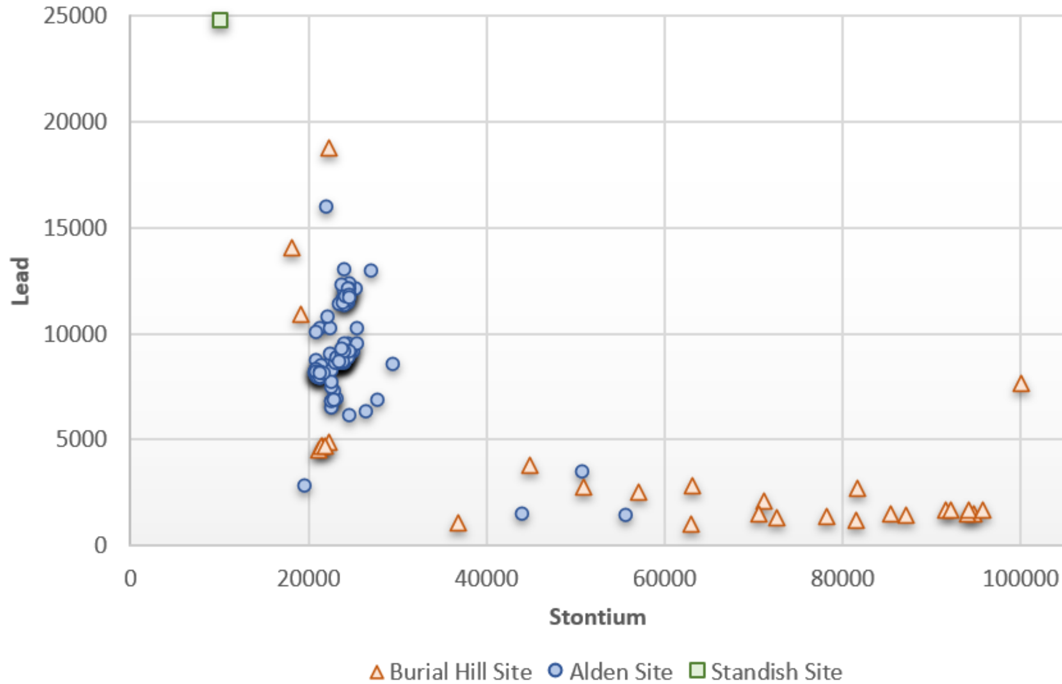

*Figure 33. Visually identified case bottles lead and strontium counts from the three sites.*

This figure shows a clear distinction between case bottles with high strontium content and case bottles with low strontium content based on their lead content, which was introduced in Figure 24 at the beginning of this chapter. This distinction is also reflected in the sites that produced the case bottle fragments. The first important conclusion from the data displayed in Figure 33, is an alteration to the identifying characteristics listed above. High strontium fragments, unless otherwise visually identified based on superficial characteristics, cannot be identified using the sample's lead content. The high lead content characteristic of identifying case bottles versus window glass can only be applied to low strontium content glass. The second important conclusion is the difference between the lead and strontium content at the Burial Hill and the Alden sites. The case bottles from the Burial Hill site trend toward high strontium and low lead content while the case bottles from the Alden site trend toward high lead and low strontium content. This difference is likely a result of the two sites being supplied with case bottles produced in different locations, although a difference in period of production is also a possibility.

The house that was on the Alden site was likely not occupied after the 17th century, while the Burial Hill site was utilized continuously after 1700, which could account for the larger range and different types of later or high strontium glass found at Burial Hill as compared to the Alden site. Although, with the understanding that the Burial Hill glass samples were only tested if they were uncovered in sealed or mixed 17th-century contexts, it is more likely that this data supports a different interpretation. These mixed 17th-century contexts produced no early 18th-century ceramics and the sealed 17th-century contexts produced only 17th-century materials. In addition, the next structure to be built on Burial Hill after the fort was deconstructed in the 1670s, was constructed in the 1760s (Beranek et. al 2015; 2018). Also, there is a higher proportion of high strontium glass at the Burial Hill site than at the Alden site.

Due to the nature of the excavated contexts and history of occupation on Burial Hill; the distinction in the visually identified case bottles; a difference in high strontium ranges between the two sites; and variation in high strontium fragment proportions, this data more likely supports the interpretation that the two sites were receiving goods produced from different glass houses. While it is possible later 18th-century glass fragments were uncovered in mixed 17th-century contexts, after all these lines of evidence are considered, the more convincing interpretation is that the occupants of these two sites procured differently produced goods.

The wider range of high strontium glass and presence of more post-1660, high strontium case bottles at Burial Hill likely represent a larger variety, and possibly “newer,” goods being utilized at that site. Compared to the Alden site, which consisted of a single family home, the Burial Hill site likely consists of at least two separate residences. The occupants of these multiple residences likely had more options and had the first pick of newer goods brought to the colonies, because of their location closer to the market center of Plymouth. This interpretation would need to be expanded to add more flat glass artifacts from Burial Hill from recent excavations to be more definitive. However, discovering this distinction of case bottle content between the two sites does add important information to this study about identification and dating of flat glass fragments.

This chapter introduced the initial results, interpretations, and statistical validation of the pXRF method established by this thesis to identify and date flat glass fragments. The next chapter presents the final identification and dating of all the flat glass fragments from the three Plymouth Colony sites.

# CHAPTER 5

# IDENTIFICATION AND DATING

## Final Results of Interpreted Data

The characteristics and stipulations of the identification method described in the previous chapter were applied to all of the glass samples tested, in order to assign a type classification and date range to each sample. All glass samples with strontium content higher than 29,000 counts were dated to after 1660, and all samples with strontium content below 29,000 counts were dated to between 1567 and 1700. For this low strontium glass, if the fragment had lead content higher than 4,293 counts it was classified as a case bottle fragment. Conversely, if the fragment was less than or equal to 3 mm in thickness and had a lead count less than 4,293, than it was classified as a window glass fragment. These results are shown in Tables 10, 11, 12, 13, and 14.

Table 10, labeled Descriptive Statistics**,** dictates the initial overall summary of the data which includes all of the glass samples minimum, maximum, mean, and standard deviation for both the overall lead and strontium content. Table 11, labeled Group Statistics**,** shows the total case bottles and window glass fragments that were able to be classified with this pXRF method with the mean, standard deviation, and standard error mean for the lead and strontium content for both types. Of the 949 fragments tested in this thesis, 80 fragments were unable to be classified, which means 92% of the collection was classified. As this method of classification is only accurate within 14%, every fragment was also visually analyzed for surface corrosion or identifying characteristics a second time, to aid in the identification. Due to the discovery of case bottles with high strontium and low lead, all high strontium flat glass, that could not be visually identified, was simply dated to a production date post-1660, and not assigned an artifact type.

Based on this distinction in the data, Table 12 displays all the classified flat glass fragments from the three sites (excluding the unclassified fragments) and Table 13 shows all of the dated and classified fragments (including the unclassified fragments). These two figures are broken down first by the three sites, then separated based on their relative strontium content, with high strontium first, followed by low strontium content. This separation is followed by the identification/classification of the fragments into case bottle and window glass. The columns with numerical data list the total number of fragments that fit into each category, the average lead content for that type of glass, the standard deviation of that category's lead content, and the standard error mean for lead values. The columns are then repeated for the strontium content statistics following the lead statistics.

Table 12 excludes the high strontium flat glass which was not visually identified. This means that there are empty cells in this chart for categories that have no visually identified high strontium glass fragments. All 949 glass fragments were included in Table 13, without the distinction between case bottle and window glass for the high strontium groups.

Therefore, in the latter table, the high strontium glass fragments data were combined in the table and marked as "combined." These tables were separated so the visually identified fragments could be plotted with the rest of the collection. These visually identified glass fragments cannot be used to establish any conclusions based on the data in Table 13.

Finally, Table 14 summarizes the elemental and physical characteristics established by this method with the associated production dates and glass type classification. Following this summary is the total number of each type of glass artifact that was classified and dated from each of the three sites.

The first of the final tables, Table 10, shows the wide range of strontium and lead values produced from the flat glass tested. The key results in this table are the averages and medians for both the strontium and lead values, which are all skewed to the lower end of the lead and strontium content ranges. This skew can be seen by comparing the mean and median values to the maximum values for both lead and the strontium content. For both of the elemental content ranges, the mean and median values are skewed toward to lower end of the range. This skew is important to take into account because it shows the high frequency for both lead and strontium counts that is in the lower side of the data range. This suggests a level of variability in the higher range of data for both lead and strontium values that was not reflected in the low values for lead and strontium. This variability in the higher range of values for strontium is likely from the variety of production locations of case bottles and window glass products with these indicative higher values. However, the variability of high lead counts, once compared to the lack of variability in the low lead counts, possibly shows an additional idea that can contribute to these interpretations.

It is possible that this high variety of high lead counts could also be from a variety of production locations that were experimenting with amounts of raw materials in glass melts as access to materials changed and different production styles came to England during the 16th and 17th centuries. As there were different types of glass makers coming to England during these centuries and access to materials changed through the period due to changing regulations and political turmoil, there is a high probability that a level of experimentation occurred which produced a higher variety in high lead counts.

Table 11 shows that a substantial amount of the collection (39%) can be classified as case bottle fragments, based on the characteristics listed previously. Of those total classified bottles, one-quarter had been cataloged before this project as window glass and the one-quarter as flat glass. This table indicates the importance of the method created in this thesis, in that all the previously identified flat glass can now be separated into more distinct artifact classes.

**Descriptive Statistics**

| | *N* | *Minimum* | *Maximum* | *Mean* | *Median* | *Std. Deviation* |
|---|---|---|---|---|---|---|
| **Lead** | 949 | 206 | 26372 | 5002 | 2935 | 4500.842 |
| **Strontium** | 949 | 2709 | 108705 | 27894 | 22064 | 21196.459 |

*Table 10. The descriptive statistics detailing all of the flat glass samples testing for this project.*

**Group Statistics**

| | *Glass Type* | *N* | *Mean* | *Std. Deviation* | *Std. Error Mean* |
|---|---|---|---|---|---|
| **Lead** | **Case Bottle** | 384 | 8257.104 | 3047.335 | 160.386 |
| | **Window Glass** | 485 | 2709.423 | 1887.889 | 83.761 |
| | **Omitted Samples** | 80 | 4877.663 | 9711.455 | 1085.774 |
| **Strontium** | **Case Bottle** | 384 | 25698.215 | 13763.246 | 724.381 |
| | **Window Glass** | 485 | 22882.877 | 9752.300 | 432.688 |
| | **Omitted Samples** | 80 | 69633.775 | 44067.429 | 4926.888 |

*Table 11. The mean lead and strontium counts for identified case bottles and window glass fragments which account for 92% of the collection.*

**Group Statistics**

| Site | Strontium Content | Glass Type | N | Mean **Lead** Content | Std. Deviation of **Lead** Content | Std. Error Mean of **Lead** Content | Mean **Strontium** Content | Std. Deviation of **Strontium** Content | Std. Error Mean of **Strontium** Content |
|---|---|---|---|---|---|---|---|---|---|
| *Alden* | High | Bottle | 4 | 3691.750 | 2906.722 | 1453.361 | 45128.500 | 9855.201 | 4927.600 |
| | | Window | 6 | 1695.333 | 621.3181 | 253.6521 | 66845.500 | 53758.32 | 21946.74 |
| | Low | Bottle | 308 | 8884.048 | 2182.656 | 123.9665 | 22550.34 | 2108.849 | 119.7746 |
| | | Window | 416 | 2263.271 | 747.5313 | 36.4758 | 22048.82 | 1333.55 | 65.0706 |
| *Burial Hill* | High | Bottle | 21 | 2130.619 | 1417.42 | 309.306 | 76506.667 | 17806.08 | 3885.605 |
| | | Window | 0 | . | . | . | . | . | . |
| | Low | Bottle | 47 | 9843.354 | 4158.473 | 702.9102 | 21414.19 | 3388.14 | 572.7002 |
| | | Window | 56 | 3313.338 | 1061.854 | 128.7687 | 22533.34 | 1638.004 | 198.6371 |
| *Standish* | High | Bottle | 0 | . | . | . | . | . | . |
| | | Window | 1 | 2084 | . | . | 157526 | . | . |
| | Low | Bottle | 4 | 18620.75 | 7341.596 | 3670.798 | 18052 | 5446.533 | 2723.267 |
| | | Window | 6 | 3662.167 | 1393.552 | 568.9153 | 21101.5 | 2535.5 | 1035.113 |

*Table 12. The lead and strontium values broken down for the case bottles and window glass fragments that were identified/classified and dated in this thesis, separated by the three sites. This table excludes the high strontium content glass that was unable to be classified.*

**Group Statistics**

| Site | Strontium Content | Glass Type | N | Mean **Lead** Content | Std. Deviation of **Lead** Content | Std. Error Mean of **Lead** Content | Mean **Strontium** Content | Std. Deviation of **Strontium** Content | Std. Error Mean of **Strontium** Content |
|---|---|---|---|---|---|---|---|---|---|
| *Alden* | High | *Combined* | 40 | 5042.675 | 6196.429 | 979.741 | 50846.000 | 15215.69 | 7149.228 |
| | Low | Bottle | 308 | 8884.048 | 2182.6556 | 123.9665 | 22550.342 | 2108.8488 | 119.7746 |
| | | Window | 416 | 2263.271 | 747.5313 | 36.4758 | 22048.821 | 1333.5503 | 65.0706 |
| *Burial Hill* | High | *Combined* | 61 | 2472.262 | 1261.51 | 174.323 | 84389.902 | 25998.44 | 4353.054 |
| | Low | Bottle | 47 | 9843.354 | 4158.4727 | 702.9102 | 21414.186 | 3388.1401 | 572.7002 |
| | | Window | 56 | 3313.338 | 1061.8538 | 128.7687 | 22533.338 | 1638.0039 | 198.6371 |
| *Standish* | High | *Combined* | 11 | 2193.545 | 498.451 | 150.288 | 66800.909 | 31807.94 | 9590.456 |
| | Low | Bottle | 4 | 18620.750 | 7341.5955 | 3670.7977 | 18052.000 | 5446.5329 | 2723.2665 |
| | | Window | 6 | 3662.167 | 1393.5522 | 568.9153 | 21101.500 | 2535.4997 | 1035.1134 |

*Table 13. The lead and strontium values broken down by the case bottles and window glass fragments that were identified/classified and dated using the method built in this thesis, separated into the three sites. This table includes the high strontium content glass that were unable to be classified and are in the "combined" rows.*

*pXRF Parameters Applied to Samples from Plymouth Colony Sites*

| High Strontium Glass: Post-Dating 1660 | | Low Strontium Glass: 1567-1700 | |
|---|---|---|---|
| Glass Type | Null | Case Bottle | Window Glass |
| *Strontium* | > 29,000 | < 29,000 | < 29,000 |
| *Lead* | Null | > 4,293 | < 4,293 |
| *Thickness* | Null | Null | < or = 3 mm |
| Sites | **Glass Post-Dating 1660** | **Case Bottles Dating to 1567-1700** | **Window Glass Dating to 1567-1700** |
| *Alden* | 40 | 308 | 416 |
| *Burial Hill* | 61 | 47 | 56 |
| *Standish* | 11 | 4 | 6 |

*Table 14. The parameters used to identify and date flat glass fragments with the totals of each group from the three sites.*

**Final Interpretation**

There are three final interpretations that can be observed from the data in the final tables. The first observation is about the low strontium glass overall. The average strontium counts in the low strontium group at all three sites are around 22,000 counts, with relatively low standard deviations and low standard error means, seen in Figures 12 and 13. This limited range in counts is potentially a sign of relatively standardized raw ingredients in

English glass making that produced similar strontium content in the glass during the period before experimentation with kelp as a flux. This high frequency of low strontium content glass at the Burial Hill and Alden sites also suggest that low strontium glass was likely easier to access throughout the 17th century as it had been produced over a wider period of time, as compared to the high strontium glass. The exception is the Standish site, which is likely an outlier as there are so few fragments from this site. All three sites do, however, have some high strontium glass represented. The presence of high strontium glass at Burial Hill and the Alden site speaks to colonists use of new products as they became available in the colonies.

The second interpretation is based on the relative representation of the high strontium glass. The Burial Hill site has fewer overall flat glass samples but produced more high strontium glass with a wider range of strontium values than the glass from the Alden site. This distinction adds to the likelihood that the glass discovered at the Burial Hill site was likely produced at a wider variety of glass houses, while the glass from the Alden site was possibly made at fewer production locations. The wider range of high strontium glass values, higher variety of goods (discussed in the previous chapter), and larger proportion of high strontium to low strontium glass at the Burial Hill site compared to the Alden site, suggests differences in access to specific goods. The occupants of Burial Hill appear to have had wider access to goods with a larger number of households. As seen in Figure 13, the high strontium group at Burial Hill has a higher strontium average than the other two sites and a higher standard deviation than the Alden site. This wider range of high strontium content glass is likely a reflection of a glass assemblage produced at different glass houses. This remains an interpretation open to further research about date ranges and production locations associated with specific high strontium values in English and other European glass houses.

The third interpretation of these tables is based on the lead content variations. The low strontium case bottle samples from the Standish site have average strontium counts that are 3000 counts lower than any other glass type for low strontium glass at the three sites. These case bottle fragments also have a significantly higher lead count than case bottles at the other sites. All of these samples have lead content above 10,000 counts, which could suggest glass from a source with greater amounts of raw lead used in the glass melt.

The idea of variable lead content based on the glass source is supported by data from five visually identified case bottle fragments from Burial Hill that are outliers in terms of elemental composition. The Burial Hill outlier case bottles were identified in a sealed 17$^{th}$-century context but had low strontium content and lead content higher than average but below that of the Standish site. While the strontium counts for these fragments are around the averages for other low strontium glass, the lead counts are just above the cut off for the lead content used for identifying fragments as case bottles (identifying count for case bottles is 4,293; case bottle outlier's average from Burial Hill is 4,698). These lead counts are relatively lower than that of the other visually identified case bottles from the three sites. It is possible that these products were made during a glass experimentation period in the 17$^{th}$ century or in glass houses outside England. With the influx of continental Europeans and growth of communication of ideas, there would have been an opportunity for experimentation of raw lead within glass melts, potentially creating these outliers. In addition to these interesting case bottle fragments, Figure 24 and 33 noted that there was a notable change in case bottle lead composition once the change to kelp ash occurred. While the outlier case bottles only represent nine glass samples, Figure 33 suggests lead content was standardized later in the 17th century, so these examples might be earlier and produced during a period in which lead experimentation in glass melts occurred.

This interpretation is strengthened by the data displayed in Figures 23 and 24, which showed evidence of all ranges of lead content in low strontium glass but only low lead content in high strontium glass. Figures 23, 24, and 33, along with these outlier samples from Burial Hill and the Standish site could suggest that various amounts of lead was used as a flux in case bottles before the use of kelp ash. Once kelp ash was introduced as a flux, it was used for all types of green glass and the lead flux was no longer used for case bottles. Lead could have also been used as a decolorizer, which was known to glass makers in England since 1567. However, the introduction of English lead crystal glass is not attributed to the English glass maker, Ravencroft, till 1676 (Dungworth 2006:453). This suggests that the English were experimenting with the addition of raw lead throughout the 17th century. Given the variation seen in the study data between case bottles composition and window glass, it is possible that experimentation with adding different raw lead amounts to a glass melt occurred differentially throughout the 17th century depending on the product being made.

There is also a possibility the case bottle outliers were produced outside of England entirely. As many of the Plymouth colonists lived outside of England before moving to the colonies and the extensive evidence of other market materials being brought from other European counties, this alternate interpretation is plausible (Tarulis 2020). Much more historic documentation and possibly isotope analysis would need to be conducted to assess this interpretation.

From the extensive testing, both with the pXRF and through statistical analysis, a better understanding of the flat glass from the three sites discussed above has been established. As well, further interpretations about the historic progression of glass manufacturing and the potential for experimentation with lead content are suggested by this data. While there are multiple interpretations for this data, with additional analysis that includes more elemental and isotopic analysis, ceramic dating, and spatial analysis, more conclusive interpretations can be reached.

CHAPTER 6

CONCLUSIONS AND FUTURE RESEARCH

The discussion in the previous chapter presents the conclusions from applying the following identifying and dating characteristics in Table 15 to flat glass from 17th-century sites. After applying these characteristics to 949 flat glass fragments additional conclusions about possible flat glass production in England and consumption in the colonies can be theorized.

| | **High Strontium Glass Post-Dating 1660** | **Low Strontium Glass 1567-1700** | |
|---|---|---|---|
| **Glass Type** | Null | Case Bottle | Window Glass |
| *Strontium* | > 29,000 | < 29,000 | < 29,000 |
| *Lead* | Null | > 4,293 | < 4,293 |
| *Thickness* | Null | Null | < or = 3 mm |

*Table 15. Final table of elemental characteristics defining classification and dating based on this thesis.*

Based on these characteristics, all 949 fragments were able to be assigned to the low or high strontium group. The low strontium group is associated with window and case bottle glass produced between 1567 and 1700. This group has also been called the HLLA (high lime-low alkali) group by archaeologists that study glass composition (Dungworth 2011). The high strontium group dates to after 1660 and was produced through the 18$^{th}$ and into the 19$^{th}$ century. This group can be associated with glass produced using kelp ash (mixed alkali glass), as confirmed by Dungworth (Dungworth 2009). This dating technique can add a terminus post quem (TPQ) to archaeological deposits or contexts at Burial Hill. Due to the excavation style and age of excavation of the Standish and Alden sites, this method of dating can only help to add further understanding of the artifacts rather than date specific deposits.

For the Alden site, there was no vertical dimension recorded over the excavated area except in the cellar of the house. This makes determining when artifacts were deposited as a means to identify when the house was abandoned, difficult to parse out. With this technique there is a possibility to help conclude more decisively the late 17$^{th}$-century occupation of the site. The raw values of at least some high strontium glass at the Alden site can speak to the use of this site before it was abandoned.

Almost half the high strontium glass was found in the bottom two layers of the cellar at this site, while the other high strontium fragments were found in the center of the structure or in units surrounding the northern foundation wall. This suggests that the high strontium glass products were utilized by the occupants of the Alden site before the structure was abandoned and not deposited at the site after the structure became a ruin. The fragments in the cellar and in the center of the structure could be case bottle fragments that were stored in the cellar or close to the chimney at the center of the structure. Case bottles could have been stored near the chimney for easy access during cooking activities around the hearth. The fragments around the northern foundation wall could be from the occupants of the home sweeping toward that wall, which was proposed in Gardiner's Master's thesis (2017).

The scatter plot shown in Figure 34 highlights four lead/strontium count clusters at the Alden site. These clusters could be useful for future analysis of the flat glass data accumulated in this thesis. Future analysis to interpret these clusters of samples at the Alden site could suggest important conclusions about artifact classifications and production site location for these clustered flat glass samples.

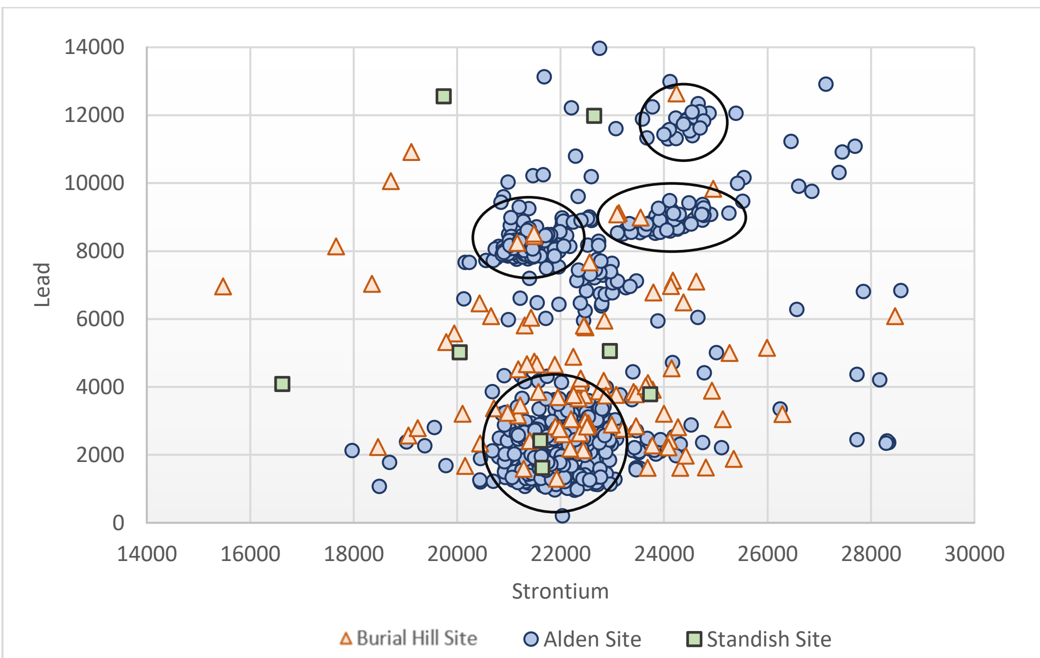


*Figure 34. Scatter plot showing four clusters of flat glass artifacts from the Alden site that could be studied in future research to determine more finite artifact classifications.*

For the Standish site, the glass dating established in this thesis can be used to help understand the limited number of artifacts that still remain in the public domain from the

19th-century excavations of the site. There are only 21 flat glass fragments from the Standish site and with the understanding of the site burning down in 1665, the presence of high strontium glass adds to the knowledge of the site being used as a dumping ground after its destruction (Heitert 2017).

As the Burial Hill site was excavated recently and has excellent depositional control, the dating of specific deposits can be used to understand when specific contexts were accumulated. Table 16 details the TPQs assigned to contexts which produced high or low strontium flat glass that was tested in this thesis. The high strontium glass was used to assign a TPQ of 1660 and low strontium glass was used to assign a TPQ of 1620 to deposits. While the start date of low strontium glass is 1567, as this is the year continental European glass craftsmen began producing a different type of glass in England, the TPQ date assigned to contexts that produced only low strontium glass is 1620. This is because Europeans first occupied Burial Hill at the end of 1620.

P1 and P2 contexts are mixed deposits that produced some 17th-century materials but do include materials that date to later periods. With the addition of the TPQ assigned to these mixed deposits, it becomes easier to understand these complicated contexts and how they relate to underlying 17th-century deposits. For the sealed 17th-century contexts (lots with two letters), one of the interesting conclusions that can be pulled from attributing TPQs to these deposits is that lot PT, which is possibly from a slumping or fill event and overlies a possible floor (lot PO) has a date of post-1660. The underlying lot PO has an earlier date than the overlying deposits of post-1620, based on the glass fragments tested from those contexts.

This analysis needs to be conducted on the entire flat glass collection from Burial Hill (excavated after 2018) to conclude more definitively on comparisons of all lots at the site.

| Context | EU | Location | Lot | Lot Description Summary | TPQ |
|---|---|---|---|---|---|
| **253** | 19 | west | P2 | General grouping of mixed 17th-c. deposits west of the crypt | 1660 |
| **258** | 17 | east | P1 | General grouping of mixed 17th -c deposits east of the crypt | 1660 |
| **260** | 17 | east | P1 | General grouping of mixed 17th -c deposits east of the crypt | 1660 |
| **268** | 17 | east | PA | “Muck” Pit | 1660 |
| **269** | 17 | east | PA | “Muck” Pit | 1660 |
| **279** | 21 | east | P1 | General grouping of mixed 17th -c deposits east of the crypt | 1660 |
| **295** | 24 | east | P1 | General grouping of mixed 17th -c deposits east of the crypt | 1660 |
| **327** | 17 | east | PB | Trench/Depression, possible fence line | 1660 |
| **361** | 27 | east | P1 | General grouping of mixed 17th -c deposits east of the crypt | 1660 |
| **369** | 27 | east | P1 | General grouping of mixed 17th -c deposits east of the crypt | 1620 |
| **374** | 27 | east | P1 | General grouping of mixed 17th -c deposits east of the crypt | 1620 |
| **376** | 27 | east | P1 | General grouping of mixed 17th -c deposits east of the crypt | 1620 |
| **378** | 27 | east | P1 | General grouping of mixed 17th -c deposits east of the crypt | 1620 |
| **389** | 27 | east | P1 | General grouping of mixed 17th -c deposits east of the crypt | 1620 |
| **393** | 28 | east | PA | “Muck” Pit | 1660 |
| **401** | 29 | west | P2 | General grouping of mixed 17th-c. deposits west of the crypt | 1620 |
| **411** | 31 | east | P1 | General grouping of mixed 17th -c deposits east of the crypt | 1660 |
| **418** | 31 | east | P1 | General grouping of mixed 17th -c deposits east of the crypt | 1620 |
| **423** | 27 | east | PI | Dark organic deposit | 1660 |
| **907** | 34 | east | P1 | General grouping of mixed 17th -c deposits east of the crypt | 1620 |
| **924** | 35 | west | PU | Fill deposit over cobbles | 1620 |
| **933** | 35 | west | PR | Cobble feature | 1620 |
| **934** | 33 | west | PT | Possible fill/slumping above possible floor | 1660 |
| **957** | 37 | east | P1 | General grouping of mixed 17th -c deposits east of the crypt | 1660 |
| **965** | 34 | east | P1 | General grouping of mixed 17th -c deposits east of the crypt | 1660 |
| **986** | 32 | west | P2 | General grouping of mixed 17th-c. deposits west of the crypt | 1660 |
| **999** | 34 | east | PA | “Muck” Pit | 1620 |
| **1003** | 33 | west | PO | Possible floor deposit | 1620 |

*Table 16. The contexts, excavation units, locations oriented to the crypt, lots and TPQ’s assigned to those contexts based on the flat glass dating of glass from Burial Hill.*

The above presentation of conclusions produced from this thesis suggest that the answer to the first research question, as production of glass evolves and diversifies, can pXRF glass analysis aid in dating archaeological artifacts or deposits, is yes. As the strontium content at the three sites suggests interpretations for the occupational use and post occupational use of these sites. This question could likely be further explored with additional spatial and statistical analysis.

The second research question, can this same pXRF testing also be used to identify different glass artifact types, can also be answered yes, because this technique was also able to classify previously cataloged “flat glass” as window or case bottle glass. This identification was able to be applied to 92% of the total fragments tested for this project with an accuracy of 86%. This can help with cataloging of fragmented artifacts that could not be identified otherwise. Before this pXRF testing was conducted 732 flat glass fragments of the total 949 were identified as either flat glass or misidentified as window glass. The majority of the misidentified window glass fragments can be correctly cataloged as case bottles and the fragments simply classified as flat glass can be further identified as window or case bottle glass. This identification can also help in future analyses to designate activity areas or use of rooms by understanding the distribution of these identified artifacts. It is important to keep in mind the level on *inaccuracy* to this method. As this method is only 86% accurate there is a possibility for misidentified fragments from this method. Depending on the use of the cataloged artifacts with spatial analysis, this method should be utilized with the understanding that it is likely not 100% accurate.

The third research question, can analyzing flat glass artifacts at the Burial Hill site, Alden site, and Standish Site in Plymouth Colony, be used to better understand tangible material connections between England and its colonies, has also been answered yes based on the analysis conducted. This thesis was able to interpret changing production styles in

England based on variations in lead and strontium content between the sites which could be used to suggest an experimental glass production period throughout the $17^{th}$ century. This is based on evidence of case bottle fragments which produced lead outlier content and the major distinction is case bottle content depicted in Figure 33. In addition to the evidence of varying ranges of strontium content between sites, this data suggests various types of experimentation with raw materials added to glass melts during different periods of the $17^{th}$ century. From these lines of evidence it is likely that glass producers in England were experimenting with different raw lead and kelp ash amounts in glass production to create a distinctly England glass production style.

The final research question presented in the chapter 1, how are changes in English glass production during the $17^{th}$ century represented in the colonies, especially as relationships between the colonies and England change, was successfully answered in the above conclusions as well as through the previously discussed high strontium content range compared across sites. These conclusions create possible chronological interpretations to how the English glass industry evolved during the $17^{th}$ century and how English colonies were supplied with glass products. In previous chapters, the wide high strontium content at Burial Hill was compared to the finer high strontium content range seen at the Alden site. This comparison, along with the distinct differences between visually identified case bottles from these two sites, speaks to the difference in access and procurement of glass products in the colonies. These variations in high strontium content and distinct differences between visually identified case bottles at these two sites could suggest that the occupants of the Burial Hill site had easier access to a wider variety and newer produced glass products. From this conclusion, this thesis was able to discuss the changing production styles that occurred in England and how those products were consumed in the colonies based on flat glass fragments uncovered in Plymouth colony.

Two possible research projects that could also come from this thesis but have not been previously presented are 1) an analysis and interpretation of the different proportions of corroded glass between the Alden and Burial Hill sites and 2) adding iron (Fe) to the elemental comparisons studied in this thesis. Future research discussing the reasons for differing amounts of corrosion of the flat glass collections at Burial Hill and the Alden site could speak to the effect of soil contaminants on glass artifacts as well as the negative effects of poor curatorial storage of archaeological collections. An analysis of iron impurities in flat glass products could suggest important conclusions about the strengthening, colorization properties, and production location of the flat glass tested based on the iron content of these artifacts.

In addition to these conclusions and places for further research, there are important limitations to this technique that need to be considered before it can be applied to a collection of flat glass. For prepping the samples of glass to be tested, while the glass does not need to be polished to create a level surface for testing, it does need to be rinsed with distilled water and should not have evidence of delamination or excessive pitting on the surface. Also, all physical characteristics of the glass should be documented before testing. This is to efficiently document identifiable glass fragments and add an additional check for corrosion of the glass surface before testing. Finally, to recreate this method, a large sample size of at least 500 total flat glass fragments is required for determining relative abundances. The exact numbers presented in this thesis will likely not be able to be repeated perfectly, but the relative abundances of high and low lead and strontium content can still be interpreted using this method. An important consideration is also that flat glass dated to after 1660 with this technique, cannot be identified as case bottle or window glass, so further elemental analysis would be needed to be for this conclusion.

This method for dating flat glass applies to green glass produced between 1567 and the 1830s, and the identification method applies to green glass produced between 1567 and 1700. This method does not apply to colorless vessel glass (English Lead glass produced in the late 17$^{th}$ century or cristallo glass produced throughout the 17$^{th}$ century), or to black bottle glass (English wine bottles popularized in the mid-17$^{th}$ century) (Godfrey 1975:150; Jones 1986:9).

This thesis was able to build a flat glass dating and identification method that can be applied to glass found at 17$^{th}$-century English colonial sites, which can then be used to interpret flat glass as a proxy for types of English glass production. Therefore, there has been a better understanding established for the connection between England and its colonies through the presence and analysis of flat glass at colonial archaeological sites. In addition this method can be replicated at other 17$^{th}$-century English colonial sites to better understand the flat glass artifacts found at these sites. If this method is applied at more sites and a complete analysis is conducted for Burial Hill, a much larger chronology can be created of flat glass throughout the English colonies. This chronology would refine this dating method and add important information about variations in elemental composition of flat glass throughout the 17$^{th}$ century.

# APPENDIX A. BURIAL HILL GLASS CATALOG

| XRF Record Number | Unit | Context | Lot | Pre-test Identification | Tested? | Strontium Content | Post-test Identification | Lead | Strontium | Thickness (mm) |
|---|---|---|---|---|---|---|---|---|---|---|
| **1** | EU21 | 279 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 1688 | 97937 | 4 |
| **2** | EU21 | 279 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 1311 | 30305 | 8 |
| **3** | EU21 | 279 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 1955 | 95939 | 2 |
| **4** | EU21 | 279 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 1787 | 86061 | 2 |
| **5** | EU21 | 279 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 1300 | 21926 | 4 |
| **6** | EU21 | 279 | P1 | Unidentified | No | | | | | |
| **7** | EU21 | 279 | P1 | Unidentified | No | | | | | |
| **8** | EU17 | 268 | PA | Unidentified | No | | | | | |
| **9** | EU17 | 268 | PA | Unidentified | No | | | | | |
| **10** | EU21 | 279 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 5949 | 22844 | 2 |
| **11** | EU21 | 279 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 6781 | 23796 | 2 |
| **12** | EU21 | 279 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3203 | 26289 | 4 |
| **13** | EU21 | 279 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3757 | 22459 | 4 |
| **14** | EU21 | 279 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 7034 | 18354 | 2 |
| **15** | EU21 | 279 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 5578 | 19943 | 4 |
| **16** | EU21 | 279 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 15053 | 22216 | 2 |
| **17** | EU21 | 279 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 1621 | 23681 | 4 |
| **18** | EU21 | 279 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 5751 | 22479 | 2 |
| **19** | EU21 | 279 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 6490 | 24378 | 2 |
| **20** | EU21 | 279 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 2565 | 19058 | 2 |
| **21** | EU21 | 279 | P1 | Unidentified | No | | | | | |
| **22** | EU21 | 279 | P1 | Unidentified | No | | | | | |
| **23** | EU21 | 279 | P1 | Unidentified | No | | | | | |
| **24** | EU27 | 361 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 14517 | 190990 | 4 |
| **25** | EU17 | 327 | PB | Unidentified | Yes | Post-1660 | Unidentifiable | 1166 | 42067 | 6 |
| **26** | EU17 | 269 | PA | Unidentified | Yes | Post-1660 | Unidentifiable | 3127 | 182404 | 4 |
| **27** | EU27 | 376 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 2608 | 22038 | 4 |
| **28** | EU24 | 295 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 3301 | 70774 | 3 |
| **29** | EU24 | 295 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 3936 | 115036 | 4 |
| **30** | EU24 | 295 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 2275 | 80750 | 4 |
| **31** | EU24 | 295 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 3319 | 115738 | 3 |
| **32** | EU24 | 295 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 3407 | 87412 | 3 |
| **33** | EU24 | 295 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 17118 | 19781 | 3 |
| **34** | EU24 | 295 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 3684 | 89169 | 4 |
| **35** | EU24 | 295 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 1670 | 20151 | 2 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **36** | EU24 | 295 | P1 | Unidentified | No | | | | | |
| **37** | EU24 | 295 | P1 | Unidentified | No | | | | | |
| **38** | EU31 | 418 | p1 | Unidentified | Yes | 1567-1700 | Case Bottle | 17883 | 21981 | 2 |
| **39** | EU31 | 418 | p1 | Unidentified | No | | | | | |
| **40** | EU31 | 418 | p1 | Unidentified | Yes | 1567-1700 | Case Bottle | 7100 | 24622 | 2 |
| **41** | EU31 | 411 | p1 | Case Bottle | Yes | Post-1660 | Case Bottle | 2865 | 63096 | 2 |
| **42** | EU31 | 411 | p1 | Case Bottle | Yes | Post-1660 | Case Bottle | 2541 | 57079 | 6 |
| **43** | EU17 | 260 | P1 | Case Bottle | Yes | Post-1660 | Case Bottle | 2089 | 71187 | 4 |
| **44** | EU17 | 260 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 2471 | 101114 | 6 |
| **45** | EU17 | 260 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 3364 | 114248 | 4 |
| **46** | EU17 | 260 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 2228 | 18470 | 4 |
| **47** | EU17 | 260 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 1790 | 85966 | 6 |
| **48** | EU17 | 260 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 2047 | 70741 | 4 |
| **49** | EU17 | 260 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 2171 | 92347 | 4 |
| **50** | EU17 | 260 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 2450 | 188357 | 4 |
| **51** | EU17 | 260 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 2067 | 51252 | 4 |
| **52** | EU17 | 260 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 2052 | 67732 | 3 |
| **53** | EU17 | 260 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3849 | 23410 | 4 |
| **54** | EU17 | 260 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 2410 | 182980 | 3 |
| **55** | EU17 | 260 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 1686 | 90699 | 6 |
| **56** | EU17 | 260 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 1815 | 90869 | 3 |
| **57** | EU17 | 260 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 3037 | 93047 | 4 |
| **58** | EU17 | 260 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 7127 | 24173 | 4 |
| **59** | EU17 | 260 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 2344 | 80255 | 2 |
| **60** | EU17 | 260 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 2490 | 89256 | 2 |
| **61** | EU17 | 260 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 3784 | 85962 | 2 |
| **62** | EU17 | 260 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 1762 | 60238 | 2 |
| **63** | EU17 | 260 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 1621 | 24315 | 3 |
| **64** | EU17 | 260 | P1 | Unidentified | No | | | | | |
| **65** | EU17 | 260 | P1 | Unidentified | No | | | | | |
| **66** | EU17 | 260 | P1 | Unidentified | No | | | | | |
| **67** | EU17 | 260 | P1 | Unidentified | No | | | | | |
| **68** | EU17 | 260 | P1 | Unidentified | No | | | | | |
| **69** | EU27 | 361 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 6261 | 33043 | 3 |
| **70** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 6456 | 20433 | 4 |
| **71** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3766 | 23076 | 3 |
| **72** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3163 | 21176 | 2 |
| **73** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3866 | 22740 | 2 |
| **74** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3889 | 24924 | 3 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **75** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 2814 | 24267 | 3 |
| **76** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3211 | 23997 | 4 |
| **77** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 8439 | 21491 | 2 |
| **78** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 6971 | 24135 | 2 |
| **79** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3914 | 23781 | 2 |
| **80** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 2417 | 24108 | 3 |
| **81** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 7664 | 22562 | 3 |
| **82** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 2221 | 24082 | 2 |
| **83** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 2790 | 19238 | 2 |
| **84** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 5801 | 22453 | 2 |
| **85** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 9831 | 24948 | 3 |
| **86** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 2928 | 22539 | 3 |
| **87** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 5809 | 21306 | 2 |
| **88** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 8512 | 21487 | 2 |
| **89** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3855 | 21572 | 2 |
| **90** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3366 | 20710 | 3 |
| **91** | EU27 | 369 | P1 | Unidentified | No | | | | | |
| **91.1** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 4999 | 25268 | 2 |
| **92** | EU27 | 369 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 2765 | 23212 | 2 |
| **93** | EU27 | 369 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 5150 | 25988 | 3 |
| **94** | EU27 | 369 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 8140 | 17658 | 2 |
| **95** | EU27 | 369 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 4127 | 22354 | 2 |
| **96** | EU27 | 369 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 4177 | 22833 | 2 |
| **97** | EU27 | 369 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3748 | 22877 | 3 |
| **98** | EU27 | 369 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3704 | 21946 | 2 |
| **99** | EU27 | 369 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 2276 | 23777 | 2 |
| **100** | EU27 | 369 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 6087 | 20653 | 3 |
| **101** | EU27 | 369 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 9114 | 23123 | 2 |
| **102** | EU27 | 369 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 2996 | 22472 | 2 |
| **103** | EU27 | 369 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 2846 | 23459 | 4 |
| **104** | EU27 | 369 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 2631 | 22369 | 3 |
| **105** | EU27 | 369 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 2137 | 22438 | 2 |
| **106** | EU27 | 369 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 2890 | 22991 | 3 |
| **107** | EU27 | 369 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 12636 | 24241 | 4 |
| **108** | EU27 | 369 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 4115 | 23687 | 5 |
| **109** | EU27 | 369 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 4548 | 24146 | 8 |
| **110** | EU27 | 369 | P1 | Unidentified | No | | | | | |
| **111** | EU27 | 369 | P1 | Unidentified | No | | | | | |
| **112** | EU27 | 369 | P1 | Unidentified | No | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **113** | EU27 | 378 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 4746 | 21490 | 2 |
| **114** | EU27 | 378 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 17791 | 21554 | 2 |
| **115** | EU27 | 378 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3049 | 25137 | 3 |
| **116** | EU27 | 378 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 2891 | 22533 | 3 |
| **117** | EU27 | 378 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 2337 | 20447 | 2 |
| **118** | EU27 | 378 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 9080 | 23092 | 3 |
| **119** | EU27 | 378 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3781 | 23454 | 4 |
| **120** | EU27 | 378 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3052 | 22205 | 2 |
| **121** | EU27 | 378 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 4244 | 22389 | 3 |
| **122** | EU27 | 378 | P1 | Unidentified | No | | | | | |
| **123** | EU27 | 378 | P1 | Unidentified | No | | | | | |
| **124** | EU27 | 378 | P1 | Unidentified | No | | | | | |
| **125** | EU27 | 378 | P1 | Unidentified | No | | | | | |
| **126** | EU24 | 295 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 1974 | 24421 | 3 |
| **127** | EU24 | 295 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 1624 | 24809 | 5 |
| **128** | EU24 | 295 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 1882 | 25348 | 4 |
| **129** | EU24 | 295 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 1588 | 21284 | 6 |
| **130** | EU24 | 295 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 2075 | 34734 | 5 |
| **131** | EU24 | 295 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 1575 | 97785 | 4 |
| **132** | EU24 | 295 | P1 | Unidentified | No | | | | | |
| **133** | EU24 | 295 | P1 | Unidentified | No | | | | | |
| **134** | EU24 | 295 | P1 | Unidentified | No | | | | | |
| **135** | EU24 | 295 | P1 | Unidentified | No | | | | | |
| **136** | EU31 | 411 | p1 | Unidentified | Yes | 1567-1700 | Window Glass | 3454 | 21221 | 2 |
| **137** | EU31 | 411 | p1 | Unidentified | Yes | 1567-1700 | Window Glass | 2838 | 21897 | 2 |
| **138** | EU31 | 411 | p1 | Unidentified | Yes | 1567-1700 | Case Bottle | 10056 | 18719 | 4 |
| **139** | EU31 | 411 | p1 | Unidentified | Yes | 1567-1700 | Case Bottle | 16929 | 21439 | 4 |
| **140** | EU31 | 411 | p1 | Unidentified | Yes | 1567-1700 | Window Glass | 2757 | 21978 | 2 |
| **141** | EU31 | 411 | p1 | Unidentified | No | | | | | |
| **142** | EU27 | 389 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3240 | 20980 | 4 |
| **143** | EU27 | 389 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3214 | 20103 | 3 |
| **144** | EU27 | 389 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 2412 | 21403 | 2 |
| **145** | EU27 | 389 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 5318 | 19790 | 4 |
| **146** | EU27 | 389 | P1 | Unidentified | No | | | | | |
| **147** | EU27 | 389 | P1 | Unidentified | No | | | | | |
| **148** | EU27 | 389 | P1 | Unidentified | No | | | | | |
| **149** | EU27 | 374 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 2832 | 22510 | 2 |
| **150** | EU27 | 374 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 6033 | 21428 | 2 |
| **151** | EU27 | 374 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3661 | 22342 | 4 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **152** | EU27 | 374 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 6959 | 15472 | 2 |
| **153** | EU17 | 268 | PA | Unidentified | Yes | Post-1660 | Unidentifiable | 2651 | 37903 | 2 |
| **154** | EU17 | 268 | PA | Unidentified | Yes | 1567-1700 | Case Bottle | 6072 | 28466 | 6 |
| **155** | EU17 | 327 | PB | Case Bottle | Yes | Post-1660 | Case Bottle | 1105 | 36831 | 4 |
| **156** | EU27 | 423 | PI | Case Bottle | Yes | Post-1660 | Case Bottle | 3820 | 44803 | 4 |
| **157** | EU17 | 258 | P1 | Case Bottle | Yes | Post-1660 | Case Bottle | 2663 | 81617 | 6 |
| **158** | EU28 | 393 | PA | Unidentified | Yes | Post-1660 | Unidentifiable | 2175 | 58428 | 2 |
| **159** | EU19 | 253 | P2 | Unidentified | Yes | Post-1660 | Unidentifiable | 80372 | 84020 | 2 |
| **160** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 4024 | 23645 | 6 |
| **161** | EU27 | 361 | P1 | Unidentified | Yes | 1567-1700 | Case Bottle | 8242 | 21161 | 3 |
| **162** | EU31 | 411 | p1 | Case Bottle | Yes | 1567-1700 | Case Bottle | 14087 | 18016 | 3 |
| **163** | EU29 | 401 | P2 | Unidentified | Yes | 1567-1700 | Case Bottle | 8989 | 23548 | 4 |
| **164** | EU21 | 279 | P1 | Case Bottle | Yes | Post-1660 | Case Bottle | 1024 | 62984 | 4 |
| **165** | EU21 | 279 | P1 | Case Bottle | Yes | Post-1660 | Case Bottle | 1395 | 78193 | 4 |
| **166** | EU21 | 279 | P1 | Case Bottle | Yes | Post-1660 | Case Bottle | 1545 | 94841 | 3 |
| **167** | EU21 | 279 | P1 | Case Bottle | Yes | Post-1660 | Case Bottle | 1301 | 72530 | 3 |
| **168** | EU21 | 279 | P1 | Case Bottle | Yes | Post-1660 | Case Bottle | 1532 | 94108 | 4 |
| **169** | EU21 | 279 | P1 | Case Bottle | Yes | Post-1660 | Case Bottle | 1470 | 87141 | 3 |
| **170** | EU21 | 279 | P1 | Case Bottle | Yes | Post-1660 | Case Bottle | 1509 | 85274 | 3 |
| **171** | EU21 | 279 | P1 | Case Bottle | Yes | Post-1660 | Case Bottle | 1645 | 94163 | 3 |
| **172** | EU21 | 279 | P1 | Case Bottle | Yes | Post-1660 | Case Bottle | 1669 | 91658 | 4 |
| **173** | EU21 | 279 | P1 | Case Bottle | Yes | Post-1660 | Case Bottle | 1648 | 95855 | 3 |
| **174** | EU21 | 279 | P1 | Case Bottle | Yes | Post-1660 | Case Bottle | 1248 | 81523 | 4 |
| **175** | EU21 | 279 | P1 | Case Bottle | Yes | Post-1660 | Case Bottle | 1696 | 92196 | 3 |
| **176** | EU21 | 279 | P1 | Case Bottle | Yes | Post-1660 | Case Bottle | 1541 | 70574 | 3 |
| **177** | EU34 | 965 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 1557 | 58529 | 2 |
| **178** | EU32 | 986 | P2 | Unidentified | Yes | Post-1660 | Unidentifiable | 2267 | 84910 | 2 |
| **179** | EU37 | 957 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 2117 | 101440 | 3 |
| **180** | EU37 | 957 | P1 | Unidentified | Yes | 1567-1700 | Window Glass | 3758 | 22250 | 4 |
| **181** | EU37 | 957 | P1 | Unidentified | Yes | Post-1660 | Unidentifiable | 2715 | 65085 | 3 |
| **182** | EU35 | 924 | PU | Unidentified | Yes | 1567-1700 | Case Bottle | 8194 | 8164 | 2 |
| **183** | EU33 | 934 | PT | Unidentified | Yes | Post-1660 | Unidentifiable | 4422 | 55643 | 3 |
| **184** | EU35 | 933 | PR | Unidentified | Yes | 1567-1700 | Window Glass | 2180 | 22181 | 2 |
| **185** | EU34 | 999 | PA | Unidentified | Yes | 1567-1700 | Case Bottle | 16412 | 20377 | 2 |
| **186** | EU35 | 905 | none | Case Bottle | Yes | Post-1660 | Case Bottle | 7693 | 100034 | 3 |
| **187** | EU35 | 905 | none | Case Bottle | Yes | Post-1660 | Case Bottle | 2744 | 50932 | 6 |
| **188** | EU34 | 907 | P1 | Case Bottle | Yes | 1567-1700 | Case Bottle | 18744 | 22310 | 3 |
| **188.1** | EU34 | 907 | p1 | Case Bottle | Yes | 1567-1700 | Case Bottle | 10919 | 19115 | 3 |
| **189** | EU33 | 1003 | PO | Case Bottle | Yes | 1567-1700 | Case Bottle | 4521 | 21181 | 2 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **190** | EU33 | 1003 | PO | Case Bottle | Yes | 1567-1700 | Case Bottle | 4661 | 21543 | 2 |
| **191** | EU33 | 1003 | PO | Case Bottle | Yes | 1567-1700 | Case Bottle | 4885 | 22247 | 2 |
| **192** | EU33 | 1003 | PO | Case Bottle | Yes | 1567-1700 | Case Bottle | 4651 | 21885 | 2 |
| **192.1** | EU33 | 1003 | PO | Case Bottle | Yes | 1567-1700 | Case Bottle | 4673 | 21348 | 3 |
| **958** | EU35 | 920 | none | Unidentified | No | | | | | |
| **959** | EU28 | 395 | PA | Unidentified | No | | | | | |
| **960** | EU28 | 395 | PA | Unidentified | No | | | | | |
| **961** | EU28 | 399 | PA | Unidentified | No | | | | | |
| **962** | EU28 | 400 | PA | Unidentified | No | | | | | |
| **963** | EU17 | 316 | PC | Unidentified | No | | | | | |
| **964** | EU17 | 316 | PC | Unidentified | No | | | | | |
| **965** | EU17 | 316 | PC | Unidentified | No | | | | | |
| **966** | EU17 | 316 | PC | Unidentified | No | | | | | |
| **967** | EU17 | 316 | PC | Unidentified | No | | | | | |
| **968** | EU17 | 316 | PC | Unidentified | No | | | | | |
| **969** | EU36 | 915 | none | Unidentified | No | | | | | |
| **970** | EU24 | 300 | PA | Unidentified | No | | | | | |
| **971** | EU24 | 300 | PA | Unidentified | No | | | | | |
| **972** | EU24 | 300 | PA | Unidentified | No | | | | | |
| **973** | EU24 | 300 | PA | Unidentified | No | | | | | |
| **974** | EU17 | 305 | PB | Unidentified | No | | | | | |
| **975** | EU17 | 305 | PB | Unidentified | No | | | | | |
| **976** | EU27 | 374 | P1 | Unidentified | No | | | | | |
| **977** | EU27 | 374 | P1 | Unidentified | No | | | | | |
| **978** | EU27 | 374 | P1 | Unidentified | No | | | | | |
| **979** | EU27 | 374 | P1 | Unidentified | No | | | | | |
| **980** | EU17 | 316 | PC | Unidentified | No | | | | | |

# APPENDIX B. STANDISH SITE GLASS CATALOG

| XRF Record Number | Unit | Strontium Content | Pre-test Identification | Post-test Identification | Lead | Strontium | Thickness (mm) |
|---|---|---|---|---|---|---|---|
| **981** | F4 | 1567-1700 | Unidentified | Case Bottle | 25200 | 19667 | 3 |
| **982** | | 1567-1700 | Case Bottle | Case Bottle | 24747 | 10152 | 2 |
| **983** | | Post-1660 | Window Glass | Window Glass | 2084 | 157526 | 2 |
| **984** | | 1567-1700 | Unidentified | Window Glass | 1617 | 21647 | 3 |
| **985** | | 1567-1700 | Unidentified | Window Glass | 4085 | 16617 | 2 |
| **986** | | Post-1660 | Unidentified | Unidentifiable | 1663 | 47989 | 2 |
| **987** | | 1567-1700 | Unidentified | Case Bottle | 5060 | 22954 | 2 |
| **988** | | 1567-1700 | Unidentified | Case Bottle | 5014 | 20046 | 2 |
| **989** | | 1567-1700 | Unidentified | Case Bottle | 11981 | 22648 | 2 |
| **990** | | Post-1660 | Unidentified | Unidentifiable | 1934 | 68064 | 2 |
| **991** | | 1567-1700 | Unidentified | Window Glass | 3781 | 23734 | 2 |
| **992** | | Post-1660 | Unidentified | Unidentifiable | 3298 | 31390 | 2 |
| **993** | | Post-1660 | Unidentified | Unidentifiable | 2052 | 69971 | 2 |
| **994** | | Post-1660 | Unidentified | Unidentifiable | 3148 | 55427 | 2 |
| **995** | | Post-1660 | Unidentified | Unidentifiable | 2038 | 32970 | 2 |
| **996** | | Post-1660 | Unidentified | Unidentifiable | 1917 | 68060 | 2 |
| **997** | | Post-1660 | Unidentified | Unidentifiable | 2060 | 67968 | 2 |
| **998** | | 1567-1700 | Unidentified | Window Glass | 2416 | 21611 | 2 |
| **999** | | Post-1660 | Unidentified | Unidentifiable | 1950 | 67450 | 2 |
| **1000** | | Post-1660 | Unidentified | Unidentifiable | 1985 | 67995 | 2 |
| **1001** | | 1567-1700 | Unidentified | Case Bottle | 12555 | 19741 | 2 |

# APPENDIX C. ALDEN SITE GLASS CATALOG

| XRF Record Number | Unit | Strontium Content | Pre-test Identification | Post-test Identification | Lead | Strontium | Thickness (mm) |
|---|---|---|---|---|---|---|---|
| **193** | F18 | 1567-1700 | Case Bottle | Case Bottle | 8721 | 24373 | 3 |
| **194** | C2 | 1567-1700 | Unidentified | Case Bottle | 8443 | 21841 | 2 |
| **195** | C2 | 1567-1700 | Window Glass | Window Glass | 1850 | 22667 | 2 |
| **196** | C2 | Post-1660 | Unidentified | Unidentifiable | 20693 | 29612 | 2 |
| **197** | F22 | 1567-1700 | Unidentified | Window Glass | 2585 | 21756 | 4 |
| **198** | F22 | 1567-1700 | Window Glass | Window Glass | 8333 | 21427 | 3 |
| **199** | F22 | 1567-1700 | Window Glass | Window Glass | 2675 | 21571 | 2 |
| **200** | F22 | 1567-1700 | Unidentified | Case Bottle | 8126 | 21557 | 2 |
| **201** | F22 | 1567-1700 | Window Glass | Window Glass | 2482 | 21760 | 2 |
| **202** | F22 | 1567-1700 | Window Glass | Window Glass | 2409 | 22925 | 2 |
| **203** | F22 | 1567-1700 | Unidentified | Window Glass | 2987 | 22366 | 3 |
| **204** | F22 | 1567-1700 | Unidentified | Case Bottle | 8026 | 21557 | 2 |
| **205** | F22 | 1567-1700 | Unidentified | Case Bottle | 8142 | 21311 | 2 |
| **206** | F22 | 1567-1700 | Unidentified | Window Glass | 1780 | 18696 | 3 |
| **207** | F22 | 1567-1700 | Unidentified | Window Glass | 2703 | 21257 | 3 |
| **208** | F22 | 1567-1700 | Unidentified | Window Glass | 2994 | 22846 | 3 |
| **209** | C2 | 1567-1700 | Unidentified | Window Glass | 3014 | 22965 | 2 |
| **210** | C2 | 1567-1700 | Unidentified | Window Glass | 1812 | 21693 | 3 |
| **211** | C2 | Post-1660 | Unidentified | Unidentifiable | 1266 | 53928 | 3 |
| **212** | C2 | 1567-1700 | Unidentified | Window Glass | 1485 | 22034 | 3 |
| **213** | C2 | 1567-1700 | Unidentified | Window Glass | 2579 | 22339 | 2 |
| **214** | C2 | 1567-1700 | Unidentified | Case Bottle | 7316 | 22526 | 2 |
| **215** | C2 | 1567-1700 | Unidentified | Case Bottle | 6388 | 22790 | 3 |
| **216** | C2 | 1567-1700 | Unidentified | Window Glass | 3024 | 22295 | 2 |
| **217** | C2 | 1567-1700 | Unidentified | Case Bottle | 8237 | 21223 | 2 |
| **218** | C2 | 1567-1700 | Unidentified | Window Glass | 3352 | 21584 | 3 |
| **219** | C2 | 1567-1700 | Window Glass | Window Glass | 5952 | 22444 | 2 |
| **220** | C2 | 1567-1700 | Unidentified | Case Bottle | 14825 | 21173 | 2 |
| **221** | C2 | 1567-1700 | Unidentified | Case Bottle | 8498 | 20995 | 2 |
| **222** | C2 | 1567-1700 | Unidentified | Window Glass | 3065 | 21952 | 3 |
| **223** | C2 | 1567-1700 | Window Glass | Window Glass | 3763 | 23152 | 2 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **224** | C2 | 1567-1700 | Window Glass | Window Glass | 1911 | 22889 | 2 |
| **225** | C2 | 1567-1700 | Window Glass | Window Glass | 6482 | 21544 | 2 |
| **226** | C2 | Post-1660 | Unidentified | Unidentifiable | 1339 | 42159 | 3 |
| **227** | C2 | Post-1660 | Unidentified | Unidentifiable | 3189 | 29243 | 3 |
| **228** | C2 | Post-1660 | Unidentified | Unidentifiable | 1384 | 54933 | 2 |
| **229** | C2 | 1567-1700 | Unidentified | Case Bottle | 11794 | 24648 | 5 |
| **230** | C2 | 1567-1700 | Unidentified | Window Glass | 1093 | 21655 | 2 |
| **231** | C2 | 1567-1700 | Unidentified | Window Glass | 2211 | 24192 | 2 |
| **232** | C2 | Post-1660 | Unidentified | Unidentifiable | 15312 | 34704 | 2 |
| **233** | C2 | 1567-1700 | Unidentified | Window Glass | 2514 | 22928 | 3 |
| **234** | C2 | Post-1660 | Unidentified | Unidentifiable | 18212 | 35420 | 2 |
| **235** | C2 | 1567-1700 | Unidentified | Case Bottle | 7913 | 21616 | 3 |
| **236** | C2 | 1567-1700 | Unidentified | Window Glass | 2539 | 22669 | 2 |
| **237** | C2 | Post-1660 | Unidentified | Unidentifiable | 1208 | 53466 | 2 |
| **238** | C2 | 1567-1700 | Unidentified | Case Bottle | 6823 | 22501 | 2 |
| **239** | C2 | 1567-1700 | Unidentified | Window Glass | 2390 | 21687 | 3 |
| **240** | C2 | Post-1660 | Unidentified | Unidentifiable | 1188 | 41843 | 2 |
| **241** | C2 | 1567-1700 | Unidentified | Window Glass | 3249 | 22428 | 3 |
| **242** | C2 | 1567-1700 | Unidentified | Case Bottle | 8267 | 21200 | 3 |
| **243** | C2 | 1567-1700 | Unidentified | Case Bottle | 8070 | 21613 | 4 |
| **244** | C2 | 1567-1700 | Unidentified | Window Glass | 1970 | 21727 | 3 |
| **245** | C2 | 1567-1700 | Unidentified | Case Bottle | 8033 | 21388 | 2 |
| **246** | C2 | 1567-1700 | Unidentified | Case Bottle | 8165 | 21033 | 3 |
| **247** | C2 | 1567-1700 | Unidentified | Case Bottle | 8051 | 21385 | 2 |
| **248** | C2 | 1567-1700 | Unidentified | Window Glass | 3205 | 20867 | 3 |
| **249** | C2 | 1567-1700 | Unidentified | Case Bottle | 8579 | 23569 | 2 |
| **250** | C2 | Post-1660 | Unidentified | Unidentifiable | 13101 | 30541 | 3 |
| **251** | C2 | 1567-1700 | Unidentified | Case Bottle | 13127 | 21682 | 2 |
| **252** | C2 | 1567-1700 | Unidentified | Case Bottle | 11885 | 23580 | 2 |
| **253** | C2 | 1567-1700 | Unidentified | Case Bottle | 11301 | 24079 | 2 |
| **254** | C2 | 1567-1700 | Unidentified | Case Bottle | 11082 | 27690 | 3 |
| **255** | C2 | 1567-1700 | Unidentified | Window Glass | 1771 | 21804 | 2 |
| **256** | C2 | 1567-1700 | Unidentified | Window Glass | 1735 | 21689 | 3 |
| **257** | C2 | 1567-1700 | Unidentified | Case Bottle | 11228 | 26456 | 3 |
| **258** | C2 | 1567-1700 | Unidentified | Case Bottle | 8635 | 22000 | 3 |
| **259** | C2 | 1567-1700 | Unidentified | Case Bottle | 7799 | 20763 | 3 |
| **260** | C2 | 1567-1700 | Unidentified | Case Bottle | 7718 | 20554 | 3 |
| **261** | C2 | Post-1660 | Unidentified | Unidentifiable | 12761 | 29044 | 2 |

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|---|---|---|---|---|---|---|---|
| **262** | C2 | 1567-1700 | Unidentified | Window Glass | 1940 | 20803 | 2 |
| **263** | C2 | 1567-1700 | Unidentified | Case Bottle | 9606 | 22338 | 2 |
| **264** | C2 | 1567-1700 | Case Bottle | Case Bottle | 12056 | 24871 | 2 |
| **265** | C2 | Post-1660 | Case Bottle | Case Bottle | 1463 | 44101 | 4 |
| **266** | C2 | Post-1660 | Case Bottle | Case Bottle | 1373 | 55863 | 6 |
| **267** | C2 | 1567-1700 | Case Bottle | Case Bottle | 11400 | 24546 | 3 |
| **268** | C2 | 1567-1700 | Case Bottle | Case Bottle | 6917 | 23263 | 4 |
| **269** | C2 | 1567-1700 | Case Bottle | Case Bottle | 10160 | 25543 | 4 |
| **270** | F28 | 1567-1700 | Unidentified | Window Glass | 3981 | 22883 | 4 |
| **271** | F28 | 1567-1700 | Unidentified | Case Bottle | 9991 | 25424 | 2 |
| **272** | F28 | 1567-1700 | Case Bottle | Case Bottle | 8389 | 22046 | 3 |
| **273** | F28 | 1567-1700 | Unidentified | Window Glass | 1138 | 22665 | 3 |
| **274** | F28 | 1567-1700 | Unidentified | Window Glass | 1275 | 23049 | 3 |
| **275** | F28 | 1567-1700 | Unidentified | Window Glass | 2607 | 21729 | 2 |
| **276** | F28 | 1567-1700 | Window Glass | Window Glass | 2799 | 22934 | 2 |
| **277** | F28 | 1567-1700 | Unidentified | Window Glass | 2159 | 22261 | 2 |
| **278** | F28 | 1567-1700 | Unidentified | Window Glass | 2146 | 23775 | 2 |
| **279** | F28 | 1567-1700 | Unidentified | Window Glass | 3417 | 22843 | 2 |
| **280** | F28 | 1567-1700 | Unidentified | Window Glass | 3662 | 21258 | 2 |
| **281** | F28 | 1567-1700 | Unidentified | Case Bottle | 8708 | 21537 | 2 |
| **282** | F28 | 1567-1700 | Unidentified | Window Glass | 1875 | 21961 | 2 |
| **283** | F28 | 1567-1700 | Unidentified | Window Glass | 2488 | 21561 | 2 |
| **284** | F28 | 1567-1700 | Unidentified | Window Glass | 2646 | 21445 | 2 |
| **285** | F24 | 1567-1700 | Unidentified | Case Bottle | 8899 | 22414 | 2 |
| **286** | F24 | 1567-1700 | Unidentified | Window Glass | 1129 | 22718 | 3 |
| **287** | F24 | 1567-1700 | Unidentified | Window Glass | 1148 | 22415 | 3 |
| **288** | F24 | 1567-1700 | Unidentified | Window Glass | 1069 | 21314 | 2 |
| **289** | F24 | 1567-1700 | Window Glass | Window Glass | 1188 | 22689 | 2 |
| **290** | F24 | 1567-1700 | Unidentified | Case Bottle | 8975 | 22031 | 2 |
| **291** | F5 | 1567-1700 | Case Bottle | Case Bottle | 8375 | 21495 | 2 |
| **292** | F4 | 1567-1700 | Window Glass | Window Glass | 1450 | 22883 | 3 |
| **293** | F8 | 1567-1700 | Unidentified | Case Bottle | 8978 | 24616 | 3 |
| **294** | F8 | 1567-1700 | Case Bottle | Case Bottle | 9367 | 24745 | 4 |
| **295** | F8 | 1567-1700 | Case Bottle | Case Bottle | 10217 | 21468 | 5 |
| **296** | F8 | 1567-1700 | Case Bottle | Case Bottle | 12059 | 25392 | 5 |
| **297** | F8 | 1567-1700 | Case Bottle | Case Bottle | 8869 | 24245 | 5 |
| **298** | F8 | 1567-1700 | Case Bottle | Case Bottle | 8172 | 22522 | 4 |
| **299** | F8 | 1567-1700 | Case Bottle | Case Bottle | 8822 | 23717 | 2 |

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|---|---|---|---|---|---|---|---|
| **300** | F8 | 1567-1700 | Case Bottle | Case Bottle | 8660 | 24019 | 4 |
| **301** | F25 | 1567-1700 | Window Glass | Window Glass | 1357 | 21379 | 5 |
| **302** | F25 | 1567-1700 | Unidentified | Window Glass | 1256 | 21077 | 3 |
| **303** | F25 | 1567-1700 | Unidentified | Case Bottle | 16011 | 21796 | 3 |
| **304** | F26 | 1567-1700 | Unidentified | Window Glass | 3483 | 22143 | 3 |
| **305** | F31 | 1567-1700 | Unidentified | Window Glass | 1678 | 21071 | 2 |
| **306** | F31 | 1567-1700 | Unidentified | Window Glass | 2208 | 25109 | 3 |
| **307** | F31 | 1567-1700 | Unidentified | Window Glass | 2439 | 21329 | 3 |
| **308** | F26 | Post-1660 | Unidentified | Unidentifiable | 3569 | 33912 | 3 |
| **309** | F26 | 1567-1700 | Unidentified | Window Glass | 1061 | 22088 | 2 |
| **310** | F26 | 1567-1700 | Unidentified | Window Glass | 3504 | 22156 | 2 |
| **311** | F26 | 1567-1700 | Unidentified | Case Bottle | 8821 | 22034 | 2 |
| **312** | F26 | 1567-1700 | Unidentified | Window Glass | 3340 | 21895 | 2 |
| **313** | F26 | 1567-1700 | Unidentified | Window Glass | 2431 | 22820 | 2 |
| **314** | F26 | 1567-1700 | Unidentified | Window Glass | 2341 | 22608 | 2 |
| **315** | F26 | 1567-1700 | Unidentified | Window Glass | 2669 | 22818 | 3 |
| **316** | F26 | 1567-1700 | Unidentified | Window Glass | 3296 | 22812 | 4 |
| **317** | F26 | Post-1660 | Unidentified | Unidentifiable | 3375 | 31840 | 2 |
| **318** | F26 | Post-1660 | Unidentified | Unidentifiable | 16734 | 29099 | 2 |
| **319** | F26 | Post-1660 | Unidentified | Unidentifiable | 23571 | 29228 | 2 |
| **320** | F31 | 1567-1700 | Unidentified | Window Glass | 2619 | 21596 | 2 |
| **321** | 59 | 1567-1700 | Window Glass | Window Glass | 3366 | 22753 | 2 |
| **322** | 59 | 1567-1700 | Unidentified | Case Bottle | 8196 | 21343 | 4 |
| **323** | 59 | 1567-1700 | Case Bottle | Case Bottle | 7892 | 21261 | 3 |
| **324** | 59 | 1567-1700 | Case Bottle | Case Bottle | 9118 | 25253 | 4 |
| **325** | 59 | Post-1660 | Unidentified | Unidentifiable | 1190 | 54724 | 6 |
| **326** | 58 | 1567-1700 | Unidentified | Window Glass | 2434 | 21782 | 5 |
| **327** | 58 | 1567-1700 | Unidentified | Window Glass | 2582 | 21782 | 2 |
| **328** | 58 | 1567-1700 | Unidentified | Window Glass | 2612 | 22069 | 3 |
| **329** | 58 | 1567-1700 | Unidentified | Case Bottle | 8158 | 21217 | 2 |
| **330** | 58 | 1567-1700 | Unidentified | Window Glass | 1789 | 21490 | 3 |
| **331** | 58 | 1567-1700 | Unidentified | Window Glass | 1577 | 21161 | 2 |
| **332** | 58 | 1567-1700 | Unidentified | Window Glass | 2496 | 22754 | 2 |
| **333** | F25 | 1567-1700 | Unidentified | Window Glass | 1332 | 20925 | 2 |
| **334** | F25 | 1567-1700 | Unidentified | Window Glass | 3501 | 22223 | 2 |
| **335** | F25 | 1567-1700 | Unidentified | Case Bottle | 8902 | 22601 | 4 |
| **336** | F25 | 1567-1700 | Unidentified | Window Glass | 1442 | 22564 | 3 |
| **337** | F22 | 1567-1700 | Window Glass | Window Glass | 2527 | 21773 | 3 |

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| **338** | F22 | 1567-1700 | Unidentified | Case Bottle | 8179 | 21124 | 3 |
| **339** | F22 | 1567-1700 | Unidentified | Case Bottle | 7922 | 21165 | 3 |
| **340** | F22 | 1567-1700 | Unidentified | Case Bottle | 8160 | 21230 | 2 |
| **341** | F22 | 1567-1700 | Case Bottle | Case Bottle | 11769 | 24622 | 3 |
| **342** | F22 | 1567-1700 | Case Bottle | Case Bottle | 8915 | 24575 | 5 |
| **343** | F22 | 1567-1700 | Unidentified | Window Glass | 1616 | 21082 | 5 |
| **344** | F22 | 1567-1700 | Unidentified | Window Glass | 2314 | 24068 | 3 |
| **345** | F22 | 1567-1700 | Unidentified | Window Glass | 1821 | 21297 | 4 |
| **346** | F22 | 1567-1700 | Unidentified | Window Glass | 2724 | 21225 | 2 |
| **347** | F22 | 1567-1700 | Unidentified | Case Bottle | 7933 | 21554 | 3 |
| **348** | F22 | 1567-1700 | Unidentified | Case Bottle | 8086 | 21429 | 4 |
| **349** | F22 | 1567-1700 | Unidentified | Window Glass | 2245 | 21247 | 2 |
| **350** | F18 | 1567-1700 | Unidentified | Window Glass | 2897 | 22547 | 2 |
| **351** | F18 | 1567-1700 | Unidentified | Window Glass | 1792 | 21383 | 3 |
| **352** | F18 | 1567-1700 | Unidentified | Case Bottle | 8171 | 21080 | 3 |
| **353** | F18 | 1567-1700 | Window Glass | Window Glass | 1199 | 20454 | 2 |
| **354** | F18 | 1567-1700 | Unidentified | Window Glass | 3223 | 22230 | 3 |
| **355** | F18 | 1567-1700 | Unidentified | Window Glass | 1518 | 21428 | 2 |
| **356** | F18 | 1567-1700 | Unidentified | Window Glass | 3219 | 22019 | 2 |
| **357** | F19 | 1567-1700 | Unidentified | Window Glass | 2408 | 22688 | 2 |
| **358** | F19 | 1567-1700 | Unidentified | Window Glass | 1933 | 21570 | 4 |
| **359** | F19 | 1567-1700 | Unidentified | Case Bottle | 7902 | 21214 | 3 |
| **360** | F19 | 1567-1700 | Unidentified | Window Glass | 1552 | 21407 | 2 |
| **361** | F19 | 1567-1700 | Unidentified | Case Bottle | 7880 | 21040 | 2 |
| **362** | F19 | 1567-1700 | Unidentified | Window Glass | 971 | 21888 | 2 |
| **363** | F19 | 1567-1700 | Unidentified | Window Glass | 2176 | 23519 | 2 |
| **364** | F19 | 1567-1700 | Window Glass | Window Glass | 2271 | 19373 | 2 |
| **365** | F19 | 1567-1700 | Unidentified | Case Bottle | 7974 | 20885 | 2 |
| **366** | F19 | 1567-1700 | Case Bottle | Case Bottle | 11747 | 24665 | 2 |
| **367** | F21 | 1567-1700 | Window Glass | Window Glass | 2677 | 21781 | 4 |
| **368** | F21 | 1567-1700 | Window Glass | Window Glass | 2557 | 21145 | 3 |
| **369** | F21 | 1567-1700 | Unidentified | Window Glass | 1485 | 21284 | 3 |
| **370** | F21 | 1567-1700 | Unidentified | Window Glass | 1607 | 21698 | 3 |
| **371** | F27 | 1567-1700 | Unidentified | Case Bottle | 7293 | 22815 | 3 |
| **372** | F27 | 1567-1700 | Unidentified | Case Bottle | 6593 | 20129 | 3 |
| **373** | F27 | 1567-1700 | Unidentified | Window Glass | 2652 | 22421 | 3 |
| **374** | F27 | 1567-1700 | Unidentified | Window Glass | 1123 | 21913 | 2 |

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| **375** | F27 | 1567-1700 | Unidentified | Window Glass | 1870 | 21786 | 3 |
| **376** | F27 | 1567-1700 | Unidentified | Case Bottle | 7767 | 21367 | 3 |
| **377** | F27 | 1567-1700 | Unidentified | Case Bottle | 9906 | 26600 | 2 |
| **378** | F27 | 1567-1700 | Unidentified | Window Glass | 2562 | 21258 | 3 |
| **379** | F27 | 1567-1700 | Window Glass | Window Glass | 1544 | 20919 | 2 |
| **380** | F27 | 1567-1700 | Unidentified | Window Glass | 1220 | 20696 | 3 |
| **381** | F27 | 1567-1700 | Unidentified | Window Glass | 2804 | 21708 | 3 |
| **382** | F27 | 1567-1700 | Unidentified | Case Bottle | 7854 | 20981 | 2 |
| **383** | F27 | 1567-1700 | Unidentified | Window Glass | 2421 | 21687 | 4 |
| **384** | F27 | 1567-1700 | Unidentified | Window Glass | 2235 | 21373 | 3 |
| **385** | F27 | 1567-1700 | Unidentified | Window Glass | 2383 | 19024 | 2 |
| **386** | F27 | 1567-1700 | Unidentified | Case Bottle | 8182 | 20989 | 2 |
| **387** | F27 | 1567-1700 | Unidentified | Window Glass | 1477 | 22367 | 2 |
| **388** | F27 | 1567-1700 | Window Glass | Window Glass | 2837 | 22437 | 2 |
| **389** | F27 | 1567-1700 | Unidentified | Window Glass | 1846 | 22947 | 3 |
| **390** | F27 | 1567-1700 | Unidentified | Window Glass | 2599 | 21234 | 3 |
| **391** | F33 | 1567-1700 | Unidentified | Window Glass | 2499 | 23081 | 2 |
| **392** | F33 | 1567-1700 | Unidentified | Window Glass | 1756 | 21663 | 3 |
| **393** | F33 | 1567-1700 | Unidentified | Window Glass | 2057 | 21445 | 2 |
| **394** | F33 | 1567-1700 | Window Glass | Window Glass | 1836 | 21372 | 4 |
| **395** | F33 | 1567-1700 | Window Glass | Window Glass | 7988 | 21494 | 3 |
| **396** | F33 | 1567-1700 | Unidentified | Window Glass | 1812 | 21898 | 2 |
| **397** | F33 | 1567-1700 | Unidentified | Window Glass | 1458 | 21279 | 3 |
| **398** | F33 | 1567-1700 | Unidentified | Window Glass | 1605 | 21067 | 2 |
| **399** | F33 | 1567-1700 | Unidentified | Window Glass | 1796 | 21407 | 2 |
| **400** | F33 | 1567-1700 | Unidentified | Window Glass | 2489 | 20817 | 3 |
| **401** | F29 | 1567-1700 | Window Glass | Window Glass | 2470 | 23083 | 2 |
| **402** | F29 | 1567-1700 | Unidentified | Window Glass | 2619 | 21541 | 3 |
| **403** | F29 | 1567-1700 | Unidentified | Window Glass | 1210 | 22197 | 2 |
| **404** | F29 | 1567-1700 | Unidentified | Window Glass | 1272 | 21488 | 2 |
| **405** | F29 | Post-1660 | Unidentified | Unidentifiable | 6785 | 288705 | 2 |
| **406** | F29 | 1567-1700 | Unidentified | Window Glass | 2202 | 21991 | 3 |
| **407** | F33 | 1567-1700 | Window Glass | Window Glass | 1683 | 19785 | 3 |
| **408** | F33 | 1567-1700 | Unidentified | Case Bottle | 10313 | 27380 | 4 |
| **409** | F33 | 1567-1700 | Unidentified | Case Bottle | 8047 | 21471 | 4 |
| **410** | F33 | 1567-1700 | Unidentified | Case Bottle | 7721 | 21833 | 3 |

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| **411** | F33 | 1567-1700 | Unidentified | Window Glass | 2457 | 21408 | 3 |
| **412** | F33 | 1567-1700 | Unidentified | Window Glass | 2927 | 22327 | 2 |
| **413** | F33 | 1567-1700 | Unidentified | Window Glass | 1504 | 21087 | 2 |
| **414** | F32 | 1567-1700 | Unidentified | Window Glass | 1700 | 21441 | 2 |
| **415** | F32 | 1567-1700 | Unidentified | Window Glass | 3353 | 26241 | 4 |
| **416** | F32 | 1567-1700 | Window Glass | Window Glass | 2359 | 22438 | 3 |
| **417** | F32 | 1567-1700 | Window Glass | Window Glass | 2646 | 21722 | 3 |
| **418** | F32 | 1567-1700 | Window Glass | Window Glass | 1394 | 22671 | 3 |
| **419** | 57 | 1567-1700 | Unidentified | Case Bottle | 7918 | 20844 | 2 |
| **420** | 57 | 1567-1700 | Unidentified | Case Bottle | 7753 | 22701 | 2 |
| **421** | 57 | 1567-1700 | Unidentified | Window Glass | 2273 | 22692 | 4 |
| **422** | 57 | 1567-1700 | Unidentified | Window Glass | 2935 | 22504 | 3 |
| **423** | 57 | 1567-1700 | Unidentified | Case Bottle | 7638 | 22995 | 3 |
| **424** | 55 | 1567-1700 | Unidentified | Case Bottle | 7824 | 21475 | 4 |
| **425** | 55 | 1567-1700 | Unidentified | Case Bottle | 7185 | 22424 | 2 |
| **426** | 55 | 1567-1700 | Unidentified | Case Bottle | 8127 | 21360 | 3 |
| **427** | 55 | 1567-1700 | Unidentified | Case Bottle | 7664 | 20155 | 2 |
| **428** | 55 | 1567-1700 | Unidentified | Window Glass | 1892 | 20450 | 2 |
| **429** | 67 | 1567-1700 | Unidentified | Window Glass | 1054 | 22207 | 2 |
| **430** | 67 | 1567-1700 | Window Glass | Window Glass | 1246 | 22349 | 5 |
| **431** | 66 | 1567-1700 | Unidentified | Window Glass | 1173 | 21374 | 4 |
| **432** | 66 | 1567-1700 | Unidentified | Case Bottle | 8458 | 21257 | 3 |
| **433** | 42 | Post-1660 | Unidentified | Unidentifiable | 1331 | 52512 | 2 |
| **434** | 47 | 1567-1700 | Window Glass | Window Glass | 1838 | 21797 | 4 |
| **435** | 47 | 1567-1700 | Unidentified | Case Bottle | 7863 | 21323 | 5 |
| **436** | 47 | 1567-1700 | Unidentified | Window Glass | 2468 | 24173 | 2 |
| **437** | 47 | 1567-1700 | Unidentified | Window Glass | 2876 | 24525 | 2 |
| **438** | 68 | 1567-1700 | Unidentified | Window Glass | 1964 | 21460 | 2 |
| **439** | 70 | 1567-1700 | Unidentified | Window Glass | 1457 | 22298 | 4 |
| **440** | 70 | 1567-1700 | Unidentified | Window Glass | 2358 | 28340 | 2 |
| **441** | 70 | 1567-1700 | Unidentified | Window Glass | 2625 | 22703 | 4 |
| **442** | 70 | 1567-1700 | Unidentified | Window Glass | 2479 | 21896 | 3 |
| **443** | 70 | 1567-1700 | Unidentified | Window Glass | 1821 | 21550 | 2 |
| **444** | 70 | 1567-1700 | Unidentified | Window Glass | 2175 | 23724 | 4 |
| **445** | 70 | 1567-1700 | Unidentified | Window Glass | 2361 | 22919 | 2 |
| **446** | 70 | 1567-1700 | Unidentified | Window Glass | 1612 | 21539 | 2 |
| **447** | 70 | 1567-1700 | Unidentified | Window Glass | 2476 | 22270 | 2 |

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| **448** | 70 | 1567-1700 | Unidentified | Case Bottle | 8507 | 21433 | 4 |
| **449** | 70 | 1567-1700 | Unidentified | Window Glass | 1706 | 21599 | 2 |
| **450** | 70 | 1567-1700 | Unidentified | Window Glass | 2643 | 21775 | 3 |
| **451** | 70 | 1567-1700 | Unidentified | Window Glass | 2108 | 23938 | 2 |
| **452** | F28 | 1567-1700 | Unidentified | Case Bottle | 8292 | 22735 | 2 |
| **453** | F28 | 1567-1700 | Unidentified | Case Bottle | 7983 | 21115 | 6 |
| **454** | F28 | 1567-1700 | Unidentified | Window Glass | 1891 | 21554 | 2 |
| **455** | F28 | 1567-1700 | Unidentified | Case Bottle | 8485 | 21817 | 3 |
| **456** | F28 | 1567-1700 | Window Glass | Window Glass | 1656 | 22520 | 3 |
| **457** | F28 | 1567-1700 | Window Glass | Window Glass | 10243 | 21664 | 3 |
| **458** | F28 | 1567-1700 | Unidentified | Window Glass | 2019 | 21402 | 4 |
| **459** | F28 | 1567-1700 | Unidentified | Window Glass | 1164 | 22372 | 3 |
| **460** | F28 | 1567-1700 | Unidentified | Window Glass | 1298 | 22331 | 3 |
| **461** | F28 | 1567-1700 | Unidentified | Window Glass | 1927 | 20969 | 2 |
| **462** | F28 | 1567-1700 | Unidentified | Window Glass | 2610 | 21177 | 5 |
| **463** | F28 | 1567-1700 | Unidentified | Window Glass | 2043 | 22309 | 4 |
| **464** | F28 | 1567-1700 | Unidentified | Window Glass | 2645 | 21313 | 2 |
| **465** | F28 | 1567-1700 | Unidentified | Window Glass | 2933 | 21429 | 3 |
| **466** | F28 | 1567-1700 | Unidentified | Window Glass | 1582 | 21656 | 2 |
| **467** | F28 | 1567-1700 | Unidentified | Window Glass | 1186 | 22299 | 2 |
| **468** | 70 | 1567-1700 | Unidentified | Window Glass | 2493 | 21892 | 3 |
| **469** | 70 | 1567-1700 | Unidentified | Window Glass | 2341 | 22042 | 4 |
| **470** | 70 | 1567-1700 | Unidentified | Window Glass | 2329 | 22287 | 4 |
| **471** | 71 | 1567-1700 | Unidentified | Window Glass | 2469 | 21270 | 2 |
| **472** | 71 | 1567-1700 | Unidentified | Case Bottle | 7929 | 21110 | 3 |
| **473** | 71 | 1567-1700 | Unidentified | Window Glass | 1361 | 21957 | 2 |
| **474** | 71 | 1567-1700 | Unidentified | Window Glass | 2316 | 22985 | 3 |
| **475** | 71 | 1567-1700 | Unidentified | Window Glass | 1555 | 21471 | 4 |
| **476** | 71 | 1567-1700 | Unidentified | Window Glass | 2539 | 24193 | 3 |
| **477** | 71 | 1567-1700 | Unidentified | Window Glass | 2355 | 21229 | 2 |
| **478** | 71 | 1567-1700 | Unidentified | Window Glass | 2655 | 21668 | 4 |
| **479** | 71 | 1567-1700 | Window Glass | Window Glass | 2648 | 21286 | 2 |
| **480** | 71 | 1567-1700 | Unidentified | Window Glass | 2614 | 21756 | 2 |
| **481** | 71 | 1567-1700 | Unidentified | Case Bottle | 8286 | 21280 | 2 |
| **482** | 69 | 1567-1700 | Case Bottle | Case Bottle | 11880 | 24435 | 2 |
| **483** | 69 | 1567-1700 | Unidentified | Window Glass | 2695 | 21323 | 6 |
| **484** | 69 | Post-1660 | Unidentified | Unidentifiable | 2679 | 35181 | 2 |
| **485** | 69 | 1567-1700 | Unidentified | Case Bottle | 7732 | 21794 | 3 |

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| **486** | 71 | 1567-1700 | Unidentified | Window Glass | 1335 | 22152 | 2 |
| **487** | 71 | 1567-1700 | Unidentified | Window Glass | 2390 | 21590 | 3 |
| **488** | F29 | 1567-1700 | Unidentified | Window Glass | 2003 | 21612 | 3 |
| **489** | F29 | 1567-1700 | Unidentified | Window Glass | 1640 | 21658 | 2 |
| **490** | F29 | 1567-1700 | Case Bottle | Case Bottle | 8647 | 24255 | 3 |
| **491** | F29 | 1567-1700 | Unidentified | Window Glass | 1073 | 18495 | 4 |
| **492** | F29 | 1567-1700 | Case Bottle | Case Bottle | 8750 | 21024 | 3 |
| **493** | F29 | Post-1660 | Window Glass | Window Glass | 2595 | 34751 | 4 |
| **494** | F29 | 1567-1700 | Unidentified | Case Bottle | 7720 | 20699 | 5 |
| **495** | F29 | 1567-1700 | Unidentified | Window Glass | 1240 | 22021 | 2 |
| **496** | F29 | 1567-1700 | Unidentified | Window Glass | 1159 | 22507 | 3 |
| **497** | F29 | 1567-1700 | Unidentified | Window Glass | 1545 | 21324 | 3 |
| **498** | F29 | 1567-1700 | Unidentified | Case Bottle | 7762 | 21152 | 2 |
| **499** | F29 | 1567-1700 | Unidentified | Window Glass | 1495 | 20913 | 3 |
| **500** | F29 | 1567-1700 | Unidentified | Window Glass | 1877 | 21609 | 2 |
| **501** | 58 | 1567-1700 | Window Glass | Window Glass | 961 | 22271 | 4 |
| **502** | 58 | 1567-1700 | Unidentified | Case Bottle | 9758 | 26856 | 2 |
| **503** | 58 | 1567-1700 | Unidentified | Case Bottle | 7829 | 21103 | 3 |
| **504** | 58 | 1567-1700 | Unidentified | Window Glass | 2312 | 24312 | 2 |
| **505** | 58 | 1567-1700 | Unidentified | Case Bottle | 8139 | 20801 | 3 |
| **506** | 58 | 1567-1700 | Unidentified | Window Glass | 2904 | 21747 | 2 |
| **507** | 58 | 1567-1700 | Unidentified | Window Glass | 1014 | 22137 | 4 |
| **508** | 58 | 1567-1700 | Unidentified | Window Glass | 2479 | 22664 | 3 |
| **509** | 58 | 1567-1700 | Unidentified | Window Glass | 2485 | 23677 | 4 |
| **510** | 58 | 1567-1700 | Case Bottle | Case Bottle | 8270 | 21004 | 2 |
| **511** | 58 | 1567-1700 | Unidentified | Window Glass | 2656 | 21781 | 2 |
| **512** | 58 | 1567-1700 | Unidentified | Window Glass | 1687 | 21192 | 2 |
| **513** | 58 | 1567-1700 | Unidentified | Window Glass | 2448 | 27731 | 2 |
| **514** | 59 | 1567-1700 | Unidentified | Case Bottle | 7850 | 21196 | 4 |
| **515** | 59 | 1567-1700 | Unidentified | Case Bottle | 7987 | 21005 | 5 |
| **516** | 59 | 1567-1700 | Unidentified | Case Bottle | 7995 | 21522 | 3 |
| **517** | 59 | 1567-1700 | Unidentified | Case Bottle | 7905 | 21260 | 4 |
| **518** | 59 | 1567-1700 | Case Bottle | Case Bottle | 7256 | 22986 | 4 |
| **519** | 59 | 1567-1700 | Unidentified | Window Glass | 1598 | 21462 | 4 |
| **520** | 59 | 1567-1700 | Unidentified | Window Glass | 2579 | 21119 | 2 |
| **521** | 59 | 1567-1700 | Unidentified | Window Glass | 2063 | 23509 | 3 |
| **522** | 59 | 1567-1700 | Unidentified | Case Bottle | 7949 | 20982 | 4 |
| **523** | 59 | 1567-1700 | Unidentified | Window Glass | 1399 | 21633 | 3 |

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|---|---|---|---|---|---|---|---|
| **524** | 59 | 1567-1700 | Window Glass | Window Glass | 2464 | 21915 | 4 |
| **525** | 59 | 1567-1700 | Unidentified | Case Bottle | 7881 | 20913 | 3 |
| **526** | 59 | 1567-1700 | Unidentified | Window Glass | 1515 | 21490 | 2 |
| **527** | 59 | 1567-1700 | Unidentified | Case Bottle | 7874 | 21539 | 2 |
| **528** | 59 | 1567-1700 | Unidentified | Window Glass | 1285 | 21505 | 2 |
| **529** | 59 | 1567-1700 | Unidentified | Case Bottle | 4328 | 20908 | 3 |
| **530** | C1 | 1567-1700 | Unidentified | Window Glass | 2130 | 17970 | 4 |
| **531** | C1 | 1567-1700 | Unidentified | Window Glass | 2692 | 22693 | 2 |
| **532** | C1 | 1567-1700 | Unidentified | Window Glass | 1653 | 21177 | 2 |
| **533** | C1 | 1567-1700 | Unidentified | Window Glass | 1213 | 21324 | 3 |
| **534** | F4 | 1567-1700 | Window Glass | Window Glass | 2704 | 22050 | 4 |
| **535** | F4 | 1567-1700 | Window Glass | Window Glass | 2949 | 21661 | 3 |
| **536** | F4 | 1567-1700 | Window Glass | Window Glass | 2079 | 22581 | 3 |
| **537** | F4 | 1567-1700 | Unidentified | Window Glass | 2986 | 21318 | 2 |
| **538** | F16 | 1567-1700 | Case Bottle | Case Bottle | 8137 | 22180 | 2 |
| **539** | C3 | Post-1660 | Unidentified | Unidentifiable | 1213 | 34575 | 4 |
| **540** | C3 | 1567-1700 | Case Bottle | Case Bottle | 6280 | 26565 | 3 |
| **541** | C3 | 1567-1700 | Case Bottle | Case Bottle | 6808 | 27851 | 3 |
| **542** | F14 | 1567-1700 | Case Bottle | Case Bottle | 15924 | 22016 | 6 |
| **543** | F14 | 1567-1700 | Case Bottle | Case Bottle | 9004 | 22553 | 3 |
| **544** | C3 | 1567-1700 | Case Bottle | Case Bottle | 6820 | 23001 | 3 |
| **545** | C3 | Post-1660 | Case Bottle | Case Bottle | 8526 | 29666 | 3 |
| **546** | F11 | 1567-1700 | Window Glass | Window Glass | 1617 | 21253 | 2 |
| **547** | C3 | 1567-1700 | Case Bottle | Case Bottle | 6744 | 22766 | 3 |
| **548** | C3 | 1567-1700 | Case Bottle | Case Bottle | 6447 | 22795 | 2 |
| **549** | C3 | Post-1660 | Unidentified | Unidentifiable | 1228 | 42602 | 2 |
| **550** | C3 | 1567-1700 | Case Bottle | Case Bottle | 6050 | 24653 | 6 |
| **551** | C3 | 1567-1700 | Case Bottle | Case Bottle | 6721 | 22867 | 5 |
| **552** | C3 | Post-1660 | Unidentified | Unidentifiable | 1209 | 42812 | 4 |
| **553** | C3 | 1567-1700 | Case Bottle | Case Bottle | 7947 | 21088 | 3 |
| **554** | F17 | 1567-1700 | Case Bottle | Case Bottle | 11913 | 24225 | 2 |
| **555** | F17 | 1567-1700 | Case Bottle | Case Bottle | 11315 | 24234 | 5 |
| **556** | F17 | 1567-1700 | Case Bottle | Case Bottle | 8777 | 23365 | 4 |
| **557** | F17 | 1567-1700 | Case Bottle | Case Bottle | 8604 | 23249 | 3 |
| **558** | F6 | 1567-1700 | Unidentified | Window Glass | 2020 | 22344 | 2 |
| **559** | F20 | 1567-1700 | Unidentified | Case Bottle | 8066 | 20736 | 3 |
| **560** | F20 | 1567-1700 | Unidentified | Case Bottle | 7906 | 20871 | 2 |

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|---|---|---|---|---|---|---|---|
| **561** | F20 | 1567-1700 | Unidentified | Window Glass | 2300 | 22520 | 2 |
| **562** | F20 | 1567-1700 | Unidentified | Window Glass | 2474 | 21546 | 3 |
| **563** | F20 | 1567-1700 | Unidentified | Window Glass | 4204 | 28166 | 3 |
| **564** | C1 | 1567-1700 | Unidentified | Window Glass | 2648 | 22637 | 3 |
| **565** | C1 | 1567-1700 | Unidentified | Case Bottle | 7995 | 21969 | 4 |
| **566** | C1 | 1567-1700 | Unidentified | Window Glass | 1730 | 21742 | 3 |
| **567** | C1 | 1567-1700 | Unidentified | Window Glass | 1184 | 21175 | 2 |
| **568** | C1 | 1567-1700 | Unidentified | Window Glass | 2025 | 23843 | 4 |
| **569** | C1 | 1567-1700 | Unidentified | Window Glass | 2261 | 22816 | 3 |
| **570** | C1 | 1567-1700 | Case Bottle | Case Bottle | 6771 | 23000 | 4 |
| **571** | C1 | 1567-1700 | Unidentified | Window Glass | 2126 | 23395 | 4 |
| **572** | C1 | 1567-1700 | Unidentified | Window Glass | 1892 | 21728 | 4 |
| **573** | C1 | 1567-1700 | Unidentified | Window Glass | 2548 | 22068 | 3 |
| **574** | C1 | 1567-1700 | Unidentified | Window Glass | 989 | 22322 | 2 |
| **575** | C1 | 1567-1700 | Unidentified | Window Glass | 2099 | 23521 | 2 |
| **576** | C1 | 1567-1700 | Unidentified | Window Glass | 2423 | 22166 | 3 |
| **577** | C1 | 1567-1700 | Unidentified | Window Glass | 2700 | 22603 | 2 |
| **578** | C1 | 1567-1700 | Unidentified | Window Glass | 1209 | 22076 | 4 |
| **579** | C1 | 1567-1700 | Unidentified | Window Glass | 1348 | 22693 | 2 |
| **580** | C1 | 1567-1700 | Unidentified | Case Bottle | 7825 | 21275 | 4 |
| **581** | C1 | 1567-1700 | Case Bottle | Case Bottle | 11545 | 24083 | 4 |
| **582** | C1 | 1567-1700 | Case Bottle | Case Bottle | 10188 | 22590 | 5 |
| **583** | C1 | 1567-1700 | Unidentified | Window Glass | 2048 | 21529 | 3 |
| **584** | C1 | 1567-1700 | Unidentified | Window Glass | 2748 | 22259 | 2 |
| **585** | C1 | 1567-1700 | Unidentified | Case Bottle | 7066 | 23007 | 2 |
| **586** | C1 | 1567-1700 | Unidentified | Case Bottle | 8073 | 21471 | 2 |
| **587** | C1 | 1567-1700 | Unidentified | Window Glass | 1570 | 22125 | 2 |
| **588** | C1 | 1567-1700 | Unidentified | Window Glass | 1138 | 22957 | 3 |
| **589** | C1 | 1567-1700 | Unidentified | Window Glass | 2572 | 21722 | 4 |
| **590** | C1 | 1567-1700 | Case Bottle | Case Bottle | 7825 | 21426 | 3 |
| **591** | C1 | 1567-1700 | Case Bottle | Case Bottle | 8761 | 24205 | 3 |
| **592** | C1 | 1567-1700 | Unidentified | Window Glass | 1621 | 21753 | 4 |
| **593** | C1 | 1567-1700 | Unidentified | Case Bottle | 8878 | 22051 | 3 |
| **594** | C1 | 1567-1700 | Unidentified | Window Glass | 2553 | 22529 | 3 |
| **595** | C1 | 1567-1700 | Unidentified | Case Bottle | 5978 | 20991 | 4 |
| **596** | C1 | 1567-1700 | Case Bottle | Case Bottle | 8024 | 20929 | 2 |
| **597** | C1 | 1567-1700 | Case Bottle | Case Bottle | 8125 | 21781 | 2 |
| **598** | F15 | 1567-1700 | Window Glass | Window Glass | 1606 | 23528 | 2 |
| **599** | F15 | 1567-1700 | Unidentified | Case Bottle | 8524 | 23829 | 4 |

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|---|---|---|---|---|---|---|---|
| **600** | F15 | 1567-1700 | Unidentified | Window Glass | 3078 | 22199 | 6 |
| **601** | F15 | 1567-1700 | Unidentified | Window Glass | 2586 | 22080 | 4 |
| **602** | F15 | 1567-1700 | Unidentified | Window Glass | 3032 | 23054 | 3 |
| **603** | F15 | 1567-1700 | Window Glass | Window Glass | 1401 | 21784 | 4 |
| **604** | F17 | 1567-1700 | Window Glass | Window Glass | 1308 | 21327 | 4 |
| **605** | F17 | 1567-1700 | Window Glass | Window Glass | 2787 | 21532 | 4 |
| **606** | F17 | 1567-1700 | Unidentified | Window Glass | 1481 | 22253 | 2 |
| **607** | F17 | Post-1660 | Unidentified | Unidentifiable | 1234 | 54992 | 3 |
| **608** | F17 | 1567-1700 | Unidentified | Window Glass | 1985 | 22470 | 3 |
| **609** | F17 | 1567-1700 | Unidentified | Window Glass | 1298 | 21435 | 2 |
| **610** | F17 | 1567-1700 | Unidentified | Window Glass | 1513 | 22229 | 3 |
| **611** | F17 | 1567-1700 | Unidentified | Case Bottle | 8248 | 21362 | 2 |
| **612** | F17 | 1567-1700 | Unidentified | Window Glass | 2453 | 22513 | 2 |
| **613** | F17 | 1567-1700 | Unidentified | Window Glass | 2132 | 23813 | 2 |
| **614** | F17 | 1567-1700 | Case Bottle | Case Bottle | 8738 | 24131 | 3 |
| **615** | F17 | 1567-1700 | Unidentified | Window Glass | 3718 | 22347 | 5 |
| **616** | F17 | 1567-1700 | Unidentified | Window Glass | 3245 | 22494 | 3 |
| **617** | F17 | 1567-1700 | Unidentified | Window Glass | 4132 | 22015 | 2 |
| **618** | F17 | 1567-1700 | Window Glass | Window Glass | 1501 | 21886 | 3 |
| **619** | F17 | 1567-1700 | Case Bottle | Case Bottle | 9022 | 24069 | 2 |
| **620** | F17 | 1567-1700 | Case Bottle | Case Bottle | 7904 | 21301 | 4 |
| **621** | F17 | 1567-1700 | Unidentified | Case Bottle | 6248 | 22472 | 3 |
| **622** | F17 | 1567-1700 | Unidentified | Window Glass | 2715 | 21637 | 2 |
| **623** | F17 | 1567-1700 | Unidentified | Window Glass | 2527 | 21523 | 2 |
| **624** | F17 | 1567-1700 | Unidentified | Case Bottle | 8137 | 21030 | 2 |
| **625** | F17 | 1567-1700 | Unidentified | Window Glass | 3622 | 21888 | 2 |
| **626** | F17 | 1567-1700 | Unidentified | Window Glass | 1875 | 21860 | 3 |
| **627** | F17 | 1567-1700 | Unidentified | Case Bottle | 8020 | 21239 | 3 |
| **628** | F17 | 1567-1700 | Unidentified | Window Glass | 2421 | 20974 | 2 |
| **629** | F17 | 1567-1700 | Unidentified | Window Glass | 1586 | 22758 | 2 |
| **630** | F17 | 1567-1700 | Unidentified | Window Glass | 2577 | 21349 | 2 |
| **631** | F17 | 1567-1700 | Unidentified | Window Glass | 2404 | 21649 | 2 |
| **632** | F17 | 1567-1700 | Unidentified | Window Glass | 3861 | 20683 | 2 |
| **633** | F17 | 1567-1700 | Unidentified | Window Glass | 1409 | 22467 | 2 |
| **634** | F17 | 1567-1700 | Unidentified | Window Glass | 3208 | 22016 | 2 |
| **636** | | 1567-1700 | Window Glass | Window Glass | 1795 | 22035 | 2 |

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|---|---|---|---|---|---|---|---|
| **637** | F16 | 1567-1700 | Window Glass | Window Glass | 2356 | 22923 | 4 |
| **638** | F16 | 1567-1700 | Case Bottle | Case Bottle | 8509 | 23208 | 3 |
| **639** | F16 | 1567-1700 | Window Glass | Window Glass | 1620 | 23461 | 4 |
| **640** | F16 | 1567-1700 | Window Glass | Window Glass | 1448 | 21940 | 3 |
| **641** | F16 | 1567-1700 | Window Glass | Window Glass | 1581 | 22127 | 3 |
| **642** | F16 | 1567-1700 | Case Bottle | Case Bottle | 8389 | 21482 | 2 |
| **643** | F16 | 1567-1700 | Unidentified | Window Glass | 2744 | 21107 | 3 |
| **644** | F16 | 1567-1700 | Unidentified | Window Glass | 2361 | 24746 | 3 |
| **645** | F16 | 1567-1700 | Unidentified | Window Glass | 1503 | 21101 | 3 |
| **646** | F16 | 1567-1700 | Window Glass | Window Glass | 4716 | 24164 | 2 |
| **647** | F16 | 1567-1700 | Unidentified | Window Glass | 1929 | 21448 | 4 |
| **648** | F16 | 1567-1700 | Unidentified | Case Bottle | 8458 | 22119 | 2 |
| **649** | F16 | 1567-1700 | Window Glass | Window Glass | 1578 | 22151 | 2 |
| **650** | F16 | 1567-1700 | Unidentified | Window Glass | 2062 | 22088 | 2 |
| **651** | F16 | 1567-1700 | Unidentified | Window Glass | 2214 | 23428 | 3 |
| **652** | F16 | 1567-1700 | Window Glass | Window Glass | 2079 | 22871 | 3 |
| **653** | F16 | 1567-1700 | Unidentified | Window Glass | 2901 | 21663 | 3 |
| **654** | F16 | 1567-1700 | Unidentified | Window Glass | 2642 | 21858 | 2 |
| **655** | F16 | 1567-1700 | Case Bottle | Case Bottle | 9194 | 24153 | 2 |
| **656** | F16 | 1567-1700 | Unidentified | Window Glass | 1432 | 21375 | 4 |
| **657** | F16 | 1567-1700 | Unidentified | Window Glass | 2319 | 23841 | 3 |
| **658** | F16 | 1567-1700 | Unidentified | Window Glass | 2780 | 21842 | 2 |
| **659** | F16 | 1567-1700 | Unidentified | Window Glass | 3306 | 22132 | 2 |
| **660** | F16 | 1567-1700 | Window Glass | Window Glass | 795 | 10531 | 2 |
| **661** | F16 | 1567-1700 | Window Glass | Window Glass | 1340 | 22769 | 3 |
| **662** | F16 | 1567-1700 | Unidentified | Window Glass | 2625 | 22813 | 3 |
| **663** | F16 | 1567-1700 | Unidentified | Window Glass | 2727 | 21026 | 2 |
| **664** | F16 | 1567-1700 | Case Bottle | Case Bottle | 9131 | 24674 | 2 |
| **665** | FM | 1567-1700 | Case Bottle | Case Bottle | 8646 | 23800 | 5 |
| **666** | FM | 1567-1700 | Case Bottle | Case Bottle | 8749 | 23900 | 6 |
| **667** | FM | 1567-1700 | Case Bottle | Case Bottle | 9079 | 24900 | 5 |
| **668** | FM | 1567-1700 | Case Bottle | Case Bottle | 8796 | 24066 | 5 |
| **669** | FM | 1567-1700 | Case Bottle | Case Bottle | 8546 | 23533 | 4 |
| **670** | FM | 1567-1700 | Case Bottle | Case Bottle | 10795 | 22291 | 3 |
| **671** | FM | 1567-1700 | Case Bottle | Case Bottle | 10027 | 20982 | 6 |

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|---|---|---|---|---|---|---|---|
| **672** | FM | 1567-1700 | Unidentified | Case Bottle | 5006 | 25010 | 3 |
| **673** | FM | 1567-1700 | Case Bottle | Case Bottle | 12341 | 24660 | 3 |
| **674** | FM | 1567-1700 | Case Bottle | Case Bottle | 9030 | 23845 | 5 |
| **675** | FM | Post-1660 | Case Bottle | Case Bottle | 3405 | 50884 | 5 |
| **676** | FM | 1567-1700 | Case Bottle | Case Bottle | 2800 | 19562 | 7 |
| **677** | FM | 1567-1700 | Case Bottle | Case Bottle | 8112 | 20893 | 7 |
| **678** | FU | 1567-1700 | Unidentified | Case Bottle | 7109 | 23098 | 2 |
| **679** | FG | 1567-1700 | Unidentified | Window Glass | 2233 | 22291 | 3 |
| **680** | FGG | Post-1660 | Unidentified | Unidentifiable | 1318 | 54085 | 2 |
| **681** | FHH | 1567-1700 | Case Bottle | Case Bottle | 8300 | 21026 | 4 |
| **682** | FHH | 1567-1700 | Unidentified | Window Glass | 1386 | 22367 | 2 |
| **683** | FHH | 1567-1700 | Case Bottle | Case Bottle | 8168 | 22732 | 2 |
| **684** | FF | 1567-1700 | Case Bottle | Case Bottle | 8910 | 24738 | 2 |
| **685** | FF | 1567-1700 | Unidentified | Window Glass | 2407 | 28309 | 5 |
| **686** | FAA | 1567-1700 | Unidentified | Window Glass | 2727 | 21839 | 4 |
| **687** | FAA | 1567-1700 | Unidentified | Case Bottle | 7216 | 22656 | 3 |
| **688** | FAA | 1567-1700 | Unidentified | Window Glass | 1505 | 21890 | 3 |
| **689** | FAA | 1567-1700 | Unidentified | Case Bottle | 8387 | 21429 | 4 |
| **690** | FV | 1567-1700 | Window Glass | Window Glass | 2629 | 21419 | 3 |
| **691** | FV | 1567-1700 | Unidentified | Case Bottle | 8188 | 21458 | 3 |
| **692** | FV | 1567-1700 | Unidentified | Window Glass | 2815 | 21785 | 4 |
| **693** | FV | 1567-1700 | Unidentified | Case Bottle | 4446 | 23396 | 3 |
| **694** | FV | 1567-1700 | Unidentified | Case Bottle | 8086 | 21640 | 3 |
| **695** | FV | Post-1660 | Window Glass | Window Glass | 1237 | 48236 | 3 |
| **696** | FV | 1567-1700 | Unidentified | Case Bottle | 8246 | 21597 | 4 |
| **697** | FV | Post-1660 | Unidentified | Unidentifiable | 2924 | 35435 | 4 |
| **698** | FV | 1567-1700 | Unidentified | Window Glass | 2688 | 21444 | 3 |
| **699** | FV | 1567-1700 | Unidentified | Window Glass | 2481 | 22443 | 3 |
| **700** | FV | 1567-1700 | Unidentified | Window Glass | 3243 | 20931 | 2 |
| **701** | FV | 1567-1700 | Unidentified | Case Bottle | 7861 | 21511 | 2 |
| **702** | FP | 1567-1700 | Unidentified | Case Bottle | 8004 | 20897 | 4 |
| **703** | FP | 1567-1700 | Unidentified | Window Glass | 1487 | 21609 | 3 |
| **704** | FX | 1567-1700 | Unidentified | Window Glass | 2573 | 21657 | 4 |
| **705** | FX | 1567-1700 | Unidentified | Window Glass | 2285 | 22152 | 4 |
| **706** | FX | 1567-1700 | Unidentified | Window Glass | 1624 | 21347 | 4 |
| **707** | FX | 1567-1700 | Unidentified | Case Bottle | 8016 | 21365 | 2 |
| **708** | FT | 1567-1700 | Unidentified | Case Bottle | 8380 | 21032 | 3 |
| **709** | FM | 1567-1700 | Unidentified | Case Bottle | 8872 | 21278 | 2 |

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|---|---|---|---|---|---|---|---|
| **710** | FM | 1567-1700 | Unidentified | Case Bottle | 9246 | 21384 | 4 |
| **711** | FM | 1567-1700 | Unidentified | Case Bottle | 7999 | 21669 | 3 |
| **712** | FM | 1567-1700 | Unidentified | Case Bottle | 8108 | 21397 | 4 |
| **713** | FM | 1567-1700 | Unidentified | Case Bottle | 7395 | 22962 | 4 |
| **714** | FM | 1567-1700 | Unidentified | Window Glass | 2673 | 21869 | 3 |
| **715** | FM | 1567-1700 | Unidentified | Window Glass | 2030 | 21390 | 2 |
| **716** | FM | Post-1660 | Window Glass | Window Glass | 1182 | 48029 | 3 |
| **717** | FM | 1567-1700 | Unidentified | Case Bottle | 7872 | 21839 | 4 |
| **718** | FM | 1567-1700 | Unidentified | Case Bottle | 8433 | 21046 | 3 |
| **719** | FM | 1567-1700 | Unidentified | Window Glass | 1693 | 21355 | 4 |
| **720** | FM | Post-1660 | Window Glass | Window Glass | 2547 | 186622 | 2 |
| **721** | FM | 1567-1700 | Case Bottle | Case Bottle | 8586 | 24115 | 4 |
| **722** | FM | Post-1660 | Unidentified | Unidentifiable | 1474 | 42528 | 5 |
| **723** | FMM | 1567-1700 | Case Bottle | Case Bottle | 7368 | 22761 | 6 |
| **724** | FNN | 1567-1700 | Unidentified | Window Glass | 2778 | 22944 | 4 |
| **725** | FNN | 1567-1700 | Unidentified | Case Bottle | 8263 | 21611 | 2 |
| **726** | FMM | 1567-1700 | Unidentified | Window Glass | 3651 | 21974 | 3 |
| **727** | FMM | 1567-1700 | Unidentified | Window Glass | 1814 | 22064 | 4 |
| **728** | FMM | 1567-1700 | Unidentified | Window Glass | 1295 | 22431 | 3 |
| **729** | FMM | 1567-1700 | Unidentified | Case Bottle | 6840 | 28577 | 3 |
| **730** | FMM | 1567-1700 | Unidentified | Window Glass | 2461 | 21179 | 2 |
| **731** | FZ | 1567-1700 | Unidentified | Window Glass | 2422 | 21605 | 2 |
| **732** | FZ | 1567-1700 | Unidentified | Window Glass | 2623 | 21313 | 2 |
| **733** | FZ | 1567-1700 | Unidentified | Case Bottle | 11840 | 24424 | 2 |
| **734** | FG | 1567-1700 | Case Bottle | Case Bottle | 8779 | 23772 | 5 |
| **735** | FG | 1567-1700 | Case Bottle | Case Bottle | 12910 | 27130 | 4 |
| **736** | FB | 1567-1700 | Unidentified | Case Bottle | 11580 | 24102 | 2 |
| **737** | FC | 1567-1700 | Case Bottle | Case Bottle | 8125 | 20983 | 4 |
| **738** | FC | 1567-1700 | Unidentified | Case Bottle | 11608 | 23070 | 2 |
| **739** | FC | 1567-1700 | Unidentified | Window Glass | 2886 | 21591 | 2 |
| **740** | FY | 1567-1700 | Unidentified | Case Bottle | 7127 | 22316 | 2 |
| **741** | FY | Post-1660 | Window Glass | Window Glass | 1261 | 41903 | 4 |
| **742** | FY | 1567-1700 | Unidentified | Case Bottle | 7452 | 22675 | 2 |
| **743** | FL | 1567-1700 | Unidentified | Window Glass | 2611 | 21565 | 4 |
| **744** | FL | 1567-1700 | Unidentified | Window Glass | 1571 | 21811 | 3 |
| **745** | FL | 1567-1700 | Unidentified | Case Bottle | 7922 | 20989 | 2 |
| **746** | FK | 1567-1700 | Unidentified | Window Glass | 2688 | 21766 | 4 |
| **747** | FK | 1567-1700 | Unidentified | Case Bottle | 5940 | 23882 | 4 |

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|---|---|---|---|---|---|---|---|
| **748** | FK | 1567-1700 | Unidentified | Case Bottle | 4418 | 24775 | 4 |
| **749** | FK | 1567-1700 | Unidentified | Case Bottle | 9600 | 20898 | 3 |
| **750** | FK | 1567-1700 | Unidentified | Window Glass | 2429 | 21757 | 3 |
| **751** | FK | 1567-1700 | Unidentified | Window Glass | 2559 | 21724 | 3 |
| **752** | FK | 1567-1700 | Unidentified | Window Glass | 1538 | 21250 | 3 |
| **753** | FK | 1567-1700 | Unidentified | Window Glass | 2468 | 21302 | 4 |
| **754** | FK | 1567-1700 | Unidentified | Window Glass | 2524 | 21665 | 2 |
| **755** | FK | 1567-1700 | Unidentified | Case Bottle | 8275 | 21503 | 4 |
| **756** | FK | 1567-1700 | Unidentified | Case Bottle | 9439 | 20846 | 4 |
| **757** | FK | 1567-1700 | Unidentified | Case Bottle | 8393 | 21466 | 2 |
| **758** | FK | 1567-1700 | Unidentified | Case Bottle | 4333 | 21233 | 2 |
| **759** | FK | 1567-1700 | Unidentified | Window Glass | 1462 | 21440 | 4 |
| **760** | FK | Post-1660 | Unidentified | Unidentifiable | 12408 | 31147 | 3 |
| **761** | FK | 1567-1700 | Unidentified | Case Bottle | 8223 | 21235 | 2 |
| **762** | FLL | 1567-1700 | Case Bottle | Case Bottle | 8549 | 23364 | 3 |
| **763** | FL | 1567-1700 | Case Bottle | Case Bottle | 12249 | 23774 | 6 |
| **764** | FL | 1567-1700 | Case Bottle | Case Bottle | 11947 | 24589 | 4 |
| **765** | FL | 1567-1700 | Case Bottle | Case Bottle | 8535 | 23099 | 6 |
| **766** | FL | 1567-1700 | Case Bottle | Case Bottle | 8696 | 24174 | 5 |
| **767** | FL | 1567-1700 | Case Bottle | Case Bottle | 8673 | 24261 | 6 |
| **768** | FL | 1567-1700 | Case Bottle | Case Bottle | 7708 | 22778 | 4 |
| **769** | FK | 1567-1700 | Case Bottle | Case Bottle | 9418 | 24480 | 3 |
| **770** | FK | 1567-1700 | Case Bottle | Case Bottle | 12106 | 24691 | 5 |
| **771** | FK | 1567-1700 | Case Bottle | Case Bottle | 11333 | 23672 | 6 |
| **772** | FK | 1567-1700 | Case Bottle | Case Bottle | 8974 | 24227 | 5 |
| **773** | FK | 1567-1700 | Case Bottle | Case Bottle | 9269 | 24767 | 5 |
| **774** | FK | 1567-1700 | Case Bottle | Case Bottle | 8555 | 23923 | 5 |
| **775** | FK | 1567-1700 | Case Bottle | Case Bottle | 8928 | 24198 | 4 |
| **776** | FK | 1567-1700 | Case Bottle | Case Bottle | 9486 | 24111 | 4 |
| **777** | FK | 1567-1700 | Case Bottle | Case Bottle | 11534 | 24500 | 5 |
| **778** | FK | 1567-1700 | Case Bottle | Case Bottle | 9052 | 24769 | 5 |
| **779** | FK | 1567-1700 | Unidentified | Window Glass | 2583 | 21259 | 5 |
| **780** | FDD | 1567-1700 | Unidentified | Case Bottle | 13973 | 22751 | 4 |
| **781** | FEE | 1567-1700 | Unidentified | Window Glass | 2979 | 21830 | 2 |
| **782** | FJ | 1567-1700 | Unidentified | Window Glass | 3703 | 22255 | 4 |
| **783** | FF | 1567-1700 | Window Glass | Window Glass | 1702 | 21558 | 3 |
| **784** | FF | 1567-1700 | Unidentified | Window Glass | 1796 | 21926 | 3 |
| **785** | FO | 1567-1700 | Unidentified | Window Glass | 1334 | 21064 | 2 |
| **786** | FO | 1567-1700 | Unidentified | Window Glass | 2608 | 21459 | 3 |

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| **787** | FO | 1567-1700 | Unidentified | Case Bottle | 8280 | 21427 | 4 |
| **788** | FO | 1567-1700 | Unidentified | Window Glass | 2476 | 21354 | 3 |
| **789** | FO | 1567-1700 | Unidentified | Case Bottle | 8085 | 21153 | 2 |
| **790** | FO | 1567-1700 | Unidentified | Window Glass | 2617 | 21146 | 3 |
| **791** | FO | 1567-1700 | Unidentified | Case Bottle | 9297 | 21197 | 3 |
| **792** | FO | 1567-1700 | Unidentified | Case Bottle | 8050 | 21538 | 2 |
| **793** | FO | 1567-1700 | Unidentified | Case Bottle | 8989 | 21038 | 4 |
| **794** | FO | 1567-1700 | Unidentified | Case Bottle | 8068 | 21033 | 4 |
| **795** | FO | 1567-1700 | Unidentified | Window Glass | 1259 | 20436 | 2 |
| **796** | FO | 1567-1700 | Unidentified | Window Glass | 2756 | 21527 | 2 |
| **797** | FO | 1567-1700 | Unidentified | Case Bottle | 10917 | 27444 | 2 |
| **798** | FS | Post-1660 | Unidentified | Unidentifiable | 1103 | 47272 | 3 |
| **799** | FS | 1567-1700 | Unidentified | Window Glass | 2114 | 20682 | 3 |
| **800** | FS | 1567-1700 | Unidentified | Case Bottle | 8348 | 21312 | 3 |
| **801** | FS | 1567-1700 | Unidentified | Window Glass | 1053 | 21706 | 2 |
| **802** | FS | 1567-1700 | Unidentified | Window Glass | 2570 | 21194 | 3 |
| **803** | FS | 1567-1700 | Unidentified | Window Glass | 1760 | 21747 | 3 |
| **804** | FS | 1567-1700 | Unidentified | Case Bottle | 8002 | 21628 | 2 |
| **805** | FS | 1567-1700 | Unidentified | Case Bottle | 8109 | 21226 | 2 |
| **806** | FS | 1567-1700 | Unidentified | Case Bottle | 4369 | 27729 | 2 |
| **807** | FS | 1567-1700 | Unidentified | Window Glass | 2682 | 21287 | 2 |
| **808** | FW | 1567-1700 | Unidentified | Window Glass | 2479 | 21855 | 3 |
| **809** | FW | 1567-1700 | Unidentified | Window Glass | 2519 | 21666 | 4 |
| **810** | FW | 1567-1700 | Unidentified | Window Glass | 2540 | 21609 | 4 |
| **811** | FW | 1567-1700 | Unidentified | Window Glass | 2317 | 22322 | 2 |
| **812** | FW | 1567-1700 | Unidentified | Case Bottle | 8133 | 21566 | 4 |
| **813** | FW | 1567-1700 | Unidentified | Window Glass | 2191 | 22407 | 4 |
| **814** | FW | 1567-1700 | Unidentified | Window Glass | 1973 | 21281 | 4 |
| **815** | FW | 1567-1700 | Unidentified | Window Glass | 2451 | 23932 | 3 |
| **816** | FW | 1567-1700 | Unidentified | Window Glass | 2525 | 21489 | 3 |
| **817** | FW | 1567-1700 | Unidentified | Case Bottle | 8050 | 21203 | 4 |
| **818** | FW | 1567-1700 | Case Bottle | Case Bottle | 11439 | 23996 | 2 |
| **819** | FW | 1567-1700 | Unidentified | Window Glass | 1782 | 21441 | 4 |
| **820** | FW | 1567-1700 | Case Bottle | Case Bottle | 12092 | 24539 | 4 |
| **821** | FN | 1567-1700 | Unidentified | Case Bottle | 7668 | 20237 | 6 |
| **822** | F16 | 1567-1700 | Window Glass | Window Glass | 1797 | 20917 | 2 |
| **823** | F16 | 1567-1700 | Case Bottle | Case Bottle | 8797 | 24525 | 2 |
| **824** | F7 | 1567-1700 | Case Bottle | Case Bottle | 8802 | 23326 | 6 |
| **825** | F7 | 1567-1700 | Unidentified | Window Glass | 2696 | 23135 | 4 |

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| **826** | F17 | 1567-1700 | Unidentified | Case Bottle | 8854 | 22247 | 3 |
| **827** | F2 | 1567-1700 | Unidentified | Case Bottle | 8925 | 22572 | 3 |
| **828** | F2 | 1567-1700 | Unidentified | Window Glass | 2442 | 22280 | 4 |
| **829** | F2 | 1567-1700 | Unidentified | Window Glass | 2581 | 21366 | 3 |
| **830** | F2 | 1567-1700 | Case Bottle | Case Bottle | 9463 | 25521 | 2 |
| **831** | F3 | 1567-1700 | Case Bottle | Case Bottle | 9082 | 24297 | 6 |
| **832** | F3 | 1567-1700 | Case Bottle | Case Bottle | 9076 | 24725 | 6 |
| **833** | F3 | 1567-1700 | Case Bottle | Case Bottle | 8910 | 23917 | 4 |
| **834** | F10 | Post-1660 | Unidentified | Unidentifiable | 1150 | 41295 | 3 |
| **835** | F10 | 1567-1700 | Case Bottle | Case Bottle | 11732 | 24374 | 3 |
| **836** | F10 | 1567-1700 | Case Bottle | Case Bottle | 8619 | 24055 | 6 |
| **837** | F4 | 1567-1700 | Case Bottle | Case Bottle | 9104 | 24186 | 6 |
| **838** | F4 | 1567-1700 | Case Bottle | Case Bottle | 11826 | 24762 | 6 |
| **839** | F1 | 1567-1700 | Unidentified | Case Bottle | 8318 | 21107 | 6 |
| **840** | F9 | 1567-1700 | Unidentified | Case Bottle | 16029 | 22022 | 2 |
| **841** | F9 | 1567-1700 | Unidentified | Case Bottle | 8128 | 21245 | 2 |
| **842** | F9 | Post-1660 | Unidentified | Unidentifiable | 2620 | 35416 | 3 |
| **843** | F9 | 1567-1700 | Unidentified | Case Bottle | 8570 | 21986 | 3 |
| **844** | F9 | 1567-1700 | Unidentified | Case Bottle | 8344 | 21245 | 4 |
| **845** | F9 | 1567-1700 | Unidentified | Window Glass | 1305 | 21623 | 3 |
| **846** | F10 | 1567-1700 | Unidentified | Window Glass | 2892 | 22459 | 4 |
| **847** | F10 | 1567-1700 | Unidentified | Window Glass | 2525 | 21548 | 3 |
| **848** | F10 | Post-1660 | Window Glass | Window Glass | 1350 | 41532 | 3 |
| **849** | F10 | 1567-1700 | Case Bottle | Case Bottle | 7878 | 21351 | 4 |
| **850** | F10 | 1567-1700 | Unidentified | Window Glass | 1768 | 21567 | 3 |
| **851** | F10 | 1567-1700 | Unidentified | Window Glass | 1825 | 21689 | 3 |
| **852** | F10 | 1567-1700 | Case Bottle | Case Bottle | 8028 | 21515 | 4 |
| **853** | F10 | 1567-1700 | Unidentified | Window Glass | 1595 | 21587 | 4 |
| **854** | F10 | 1567-1700 | Unidentified | Case Bottle | 7314 | 22573 | 3 |
| **855** | F10 | 1567-1700 | Unidentified | Window Glass | 1863 | 21322 | 4 |
| **856** | F10 | 1567-1700 | Case Bottle | Case Bottle | 8620 | 23623 | 3 |
| **857** | F5 | 1567-1700 | Case Bottle | Case Bottle | 12989 | 24116 | 5 |
| **858** | F5 | 1567-1700 | Case Bottle | Case Bottle | 8165 | 21378 | 5 |
| **859** | F1 | 1567-1700 | Unidentified | Case Bottle | 8303 | 21688 | 3 |
| **860** | F1 | 1567-1700 | Unidentified | Window Glass | 2441 | 21573 | 3 |
| **861** | F1 | 1567-1700 | Unidentified | Window Glass | 3998 | 22415 | 3 |
| **862** | F1 | 1567-1700 | Window Glass | Window Glass | 2437 | 22944 | 3 |
| **863** | F1 | 1567-1700 | Unidentified | Window Glass | 2613 | 21682 | 4 |

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| **864** | F3 | 1567-1700 | Window Glass | Window Glass | 3023 | 22695 | 3 |
| **865** | F3 | 1567-1700 | Unidentified | Window Glass | 3626 | 23379 | 3 |
| **866** | F3 | 1567-1700 | Unidentified | Case Bottle | 6609 | 21221 | 3 |
| **867** | F3 | 1567-1700 | Unidentified | Window Glass | 1275 | 21825 | 4 |
| **868** | F3 | 1567-1700 | Unidentified | Window Glass | 2607 | 21564 | 4 |
| **869** | F3 | 1567-1700 | Unidentified | Window Glass | 4175 | 21572 | 4 |
| **870** | F3 | 1567-1700 | Unidentified | Window Glass | 2652 | 21363 | 3 |
| **871** | F3 | 1567-1700 | Unidentified | Window Glass | 3491 | 21946 | 3 |
| **872** | F3 | 1567-1700 | Unidentified | Window Glass | 1333 | 22070 | 3 |
| **873** | F11 | 1567-1700 | Unidentified | Case Bottle | 7955 | 20905 | 3 |
| **874** | F11 | 1567-1700 | Unidentified | Case Bottle | 7855 | 21606 | 2 |
| **875** | F11 | 1567-1700 | Unidentified | Case Bottle | 7825 | 21449 | 2 |
| **876** | F11 | 1567-1700 | Unidentified | Case Bottle | 24200 | 2709 | 2 |
| **877** | F11 | 1567-1700 | Unidentified | Case Bottle | 8131 | 21073 | 2 |
| **878** | F11 | 1567-1700 | Unidentified | Case Bottle | 8957 | 22518 | 3 |
| **879** | F11 | 1567-1700 | Unidentified | Window Glass | 2340 | 28294 | 3 |
| **880** | F11 | 1567-1700 | Unidentified | Window Glass | 1943 | 21677 | 3 |
| **881** | F11 | 1567-1700 | Unidentified | Case Bottle | 8395 | 21303 | 2 |
| **882** | F11 | 1567-1700 | Unidentified | Case Bottle | 8084 | 21092 | 3 |
| **883** | F11 | 1567-1700 | Unidentified | Case Bottle | 7122 | 23464 | 2 |
| **884** | F11 | 1567-1700 | Unidentified | Case Bottle | 6017 | 21713 | 4 |
| **885** | F11 | 1567-1700 | Unidentified | Case Bottle | 7844 | 21433 | 2 |
| **886** | F11 | 1567-1700 | Unidentified | Case Bottle | 8279 | 21194 | 2 |
| **887** | F11 | 1567-1700 | Unidentified | Case Bottle | 7194 | 21395 | 2 |
| **888** | F11 | 1567-1700 | Unidentified | Case Bottle | 8012 | 21299 | 3 |
| **889** | F11 | 1567-1700 | Unidentified | Window Glass | 4155 | 21304 | 2 |
| **890** | F11 | 1567-1700 | Window Glass | Window Glass | 2645 | 21505 | 3 |
| **891** | F11 | 1567-1700 | Unidentified | Case Bottle | 8156 | 21393 | 2 |
| **892** | F11 | 1567-1700 | Unidentified | Window Glass | 2018 | 20925 | 3 |
| **893** | F11 | 1567-1700 | Unidentified | Case Bottle | 8663 | 21393 | 3 |
| **894** | F11 | 1567-1700 | Window Glass | Window Glass | 2522 | 21657 | 3 |
| **895** | F11 | 1567-1700 | Unidentified | Case Bottle | 7854 | 21483 | 4 |
| **896** | F11 | 1567-1700 | Unidentified | Case Bottle | 8473 | 21805 | 3 |
| **897** | F8 | 1567-1700 | Unidentified | Window Glass | 2349 | 22747 | 4 |
| **898** | F8 | 1567-1700 | Unidentified | Case Bottle | 8609 | 21352 | 4 |
| **899** | F8 | 1567-1700 | Unidentified | Window Glass | 1881 | 21686 | 4 |
| **900** | F8 | 1567-1700 | Unidentified | Window Glass | 2880 | 20913 | 3 |
| **901** | F8 | 1567-1700 | Unidentified | Case Bottle | 7537 | 21961 | 3 |

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| **902** | F8 | 1567-1700 | Unidentified | Window Glass | 2020 | 21923 | 3 |
| **903** | F8 | 1567-1700 | Unidentified | Case Bottle | 7442 | 22343 | 3 |
| **904** | F8 | 1567-1700 | Unidentified | Case Bottle | 8795 | 23666 | 3 |
| **905** | F8 | 1567-1700 | Case Bottle | Case Bottle | 8050 | 21884 | 5 |
| **906** | F8 | 1567-1700 | Unidentified | Window Glass | 3408 | 21160 | 5 |
| **907** | F8 | 1567-1700 | Unidentified | Case Bottle | 8183 | 21179 | 4 |
| **908** | F8 | 1567-1700 | Unidentified | Case Bottle | 7857 | 21883 | 4 |
| **909** | F8 | 1567-1700 | Unidentified | Window Glass | 1541 | 21717 | 2 |
| **910** | F8 | 1567-1700 | Unidentified | Case Bottle | 6430 | 21970 | 3 |
| **911** | F8 | 1567-1700 | Case Bottle | Case Bottle | 8081 | 21426 | 3 |
| **912** | F5 | 1567-1700 | Unidentified | Window Glass | 1797 | 21589 | 2 |
| **913** | F5 | 1567-1700 | Unidentified | Window Glass | 3643 | 21722 | 2 |
| **914** | F5 | 1567-1700 | Unidentified | Window Glass | 1868 | 21995 | 3 |
| **915** | F5 | 1567-1700 | Unidentified | Window Glass | 1964 | 22020 | 2 |
| **916** | F5 | 1567-1700 | Window Glass | Window Glass | 2660 | 21297 | 3 |
| **917** | F5 | 1567-1700 | Unidentified | Window Glass | 1675 | 22211 | 2 |
| **918** | F5 | 1567-1700 | Unidentified | Window Glass | 1700 | 22054 | 2 |
| **919** | F5 | 1567-1700 | Unidentified | Window Glass | 1773 | 21983 | 2 |
| **920** | F5 | 1567-1700 | Unidentified | Case Bottle | 8310 | 21007 | 2 |
| **921** | F5 | 1567-1700 | Unidentified | Window Glass | 1263 | 22563 | 3 |
| **922** | F5 | 1567-1700 | Unidentified | Case Bottle | 8276 | 21531 | 3 |
| **923** | F5 | 1567-1700 | Unidentified | Case Bottle | 6963 | 23339 | 4 |
| **924** | F5 | 1567-1700 | Unidentified | Window Glass | 1717 | 21811 | 3 |
| **925** | F5 | 1567-1700 | Unidentified | Case Bottle | 8168 | 21021 | 4 |
| **926** | F5 | 1567-1700 | Unidentified | Case Bottle | 12213 | 22209 | 4 |
| **927** | F5 | 1567-1700 | Unidentified | Window Glass | 206 | 22036 | 4 |
| **928** | F5 | 1567-1700 | Unidentified | Window Glass | 2749 | 21559 | 3 |
| **929** | F7 | 1567-1700 | Unidentified | Window Glass | 2548 | 21743 | 4 |
| **930** | F7 | 1567-1700 | Case Bottle | Case Bottle | 11621 | 24698 | 2 |
| **931** | F7 | 1567-1700 | Unidentified | Window Glass | 1979 | 24230 | 5 |
| **932** | F7 | 1567-1700 | Unidentified | Window Glass | 2802 | 21935 | 2 |
| **933** | F7 | 1567-1700 | Unidentified | Window Glass | 2724 | 21506 | 2 |
| **934** | F7 | 1567-1700 | Unidentified | Case Bottle | 8103 | 21480 | 2 |
| **935** | F7 | 1567-1700 | Unidentified | Case Bottle | 4315 | 21738 | 2 |
| **936** | F7 | 1567-1700 | Case Bottle | Case Bottle | 9257 | 23894 | 4 |
| **937** | F7 | 1567-1700 | Unidentified | Window Glass | 2027 | 21105 | 5 |
| **938** | F4 | 1567-1700 | Unidentified | Window Glass | 3115 | 22536 | 2 |
| **939** | F4 | 1567-1700 | Window Glass | Window Glass | 2002 | 21430 | 3 |

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| **940** | F4 | 1567-1700 | Unidentified | Window Glass | 1563 | 23460 | 2 |
| **941** | F4 | 1567-1700 | Unidentified | Case Bottle | 8296 | 21209 | 4 |
| **942** | F4 | 1567-1700 | Unidentified | Case Bottle | 8898 | 22397 | 3 |
| **943** | F4 | 1567-1700 | Unidentified | Case Bottle | 8146 | 22062 | 4 |
| **944** | F4 | 1567-1700 | Unidentified | Window Glass | 1773 | 21751 | 3 |
| **945** | F4 | 1567-1700 | Unidentified | Window Glass | 1922 | 21495 | 2 |
| **946** | F4 | 1567-1700 | Unidentified | Window Glass | 2565 | 22855 | 2 |
| **947** | F4 | 1567-1700 | Unidentified | Window Glass | 2579 | 21182 | 2 |
| **948** | F4 | 1567-1700 | Unidentified | Case Bottle | 8489 | 21752 | 2 |
| **949** | F4 | 1567-1700 | Window Glass | Window Glass | 1961 | 21625 | 3 |
| **950** | F4 | 1567-1700 | Unidentified | Window Glass | 3596 | 22538 | 4 |
| **951** | F4 | 1567-1700 | Window Glass | Window Glass | 2706 | 23464 | 4 |
| **952** | F4 | 1567-1700 | Unidentified | Case Bottle | 8065 | 21458 | 4 |
| **953** | F4 | 1567-1700 | Unidentified | Case Bottle | 7501 | 21723 | 2 |
| **954** | F4 | 1567-1700 | Window Glass | Window Glass | 2732 | 21904 | 2 |
| **955** | F4 | 1567-1700 | Unidentified | Window Glass | 3348 | 22802 | 2 |
| **956** | F4 | 1567-1700 | Unidentified | Case Bottle | 8453 | 21707 | 2 |
| **957** | F4 | 1567-1700 | Unidentified | Case Bottle | 6470 | 22385 | 4 |

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